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[Article by N.V. Kornilov and Ya.L. Linetskiy, Moscow Steels and Alloys Institute; UDC 669:537.623:85/.86]

[Abstract] The effects of spraying temperature and heat treatment on the atomic structure and intensity of magnetization in Nd-Fe-Be films were studied. Sprayed magnets were produced by ion-plasma spraying argon onto cast copper or tantalum substrates (targets) at a rate of 20-40 μm/h. A chromel-alumel thermocouple located on the backside of the substrate was used to measure substrate temperature. The magnetic properties of films 50 to 200 μm thick were measured after the films had been subjected to electrolytic etching to remove the transition layer formed between the film and substrate during spraying. The measurements were taken on a vibration magnetometer with a maximum field of 2,500 kA/m. Some of the films were premagnetized in a pulse field of 7,600 kA/m. The films' magnetic properties were measured both perpendicular to the spraying plane and in the plane of the films. The films were subjected to x-ray studies on a DRON-3M diffractometer, and the chemical composition of the films and targets was determined by the atomic-emission spectral method. The sprayed alloys were found to have chemical compositions close to those of the targets; however, they also contained copper that entered the film as a result of spraying the target holder. At substrate temperatures of 450°C, the films contained the following (%): Nd, 37.4; Fe, 60.5; B, 1.38; Al, 0.15; and Cu, 0.65. At substrate temperatures of 700°C, the films contained the following (%): Nd, 36.3; Fe, 62.1; B, 1.3; Al, 0.14; and Cu, 0.16. At spraying temperatures below 450°C, the films turned out to be magnetically soft. For the said films, the residual intensity of magnetization [M_r] perpendicular to the spraying plane increased sharply during heat treatment at 700°C for 30 minutes. At substrate temperatures of $\geq$500°C, the films had a high M_r perpendicular to the spraying plane directly after spraying; however, subsequently heat treatment did not have any noticeable effect on either M_r or the intensity of magnetization in the maximum field [M_s] perpendicular to the spraying plane. In the case of films sprayed at 400°C and heat-treated at 700°C, magnetization in a pulse field increased both M_r and M_s perpendicular to the spraying plane. It had virtually no effect on the intensity of magnetization of films sprayed at higher substrate temperatures versus the values obtained in a field of 2,500 kA/m, however. The change in intensity of magnetization as a function of substrate temperature that was discovered was hypothesized to be due to changes in crystal texture. This hypothesis was confirmed by x-ray phase studies of the sprayed alloys. The minimum M_r perpendicular to the spraying plane corresponded to the minimum degree of texture, i.e., [001], and the development of a second component of texture, i.e., [102]. During spraying, perpendicular anisotropy forms even in an amorphous structure. This anisotropy, just like magnetic hysteresis, is intensified by heat treatment that transforms the alloy into a crystal state. After such treatment, films have high residual intensities of magnetization in the direction of the normal. Figures 5; references 4: 1 Russian, 3 Western.

Predicting the Mechanical Properties of Composite Materials

937D0140E Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 5, May 93 (manuscript received 10 Mar 92) pp 54-58

[Article by S.V. Tverdokhlebova, Dnepropetrovsk State University; UDC 621.791.92:389.6.543]

[Abstract] Three types of composite materials were studied to gather data that could be used to predict the mechanical properties of composite materials. The following materials were studied: 1) iron-tungsten-carbon materials filled with refractory tungsten carbide granules and a matrix binder holding them (its main structural components included a binary eutectic based on an alloyed α-solid solution of carbon in iron and an η-phase along the relit [transliteration] grain boundaries; 2) iron-boron-carbon materials with a natural filler of single-crystal Fe_2B fibers located in an $Fe_3(B, C)$ shell and an $Fe\text{-}Fe_2B+Fe\text{-}Fe_3(B, C)$ eutectic matrix produced by electric arc submerged-arc surfacing of PP-DB-01 powder wire resulting in alloying of the starting structure; and 3) high-chromium iron-boron-carbon alloys with a natural filler of fine Me_7C_3 and borides with a complexly structured eutectic matrix. The materials' abrasive wear-resistance, compression strength, and flexural strength were determined. The heterogeneity characteristics of the matrix of each material was also determined quantitatively. A statistical method that included correlation, regression, and variance analyses was used to predict the mechanical properties of each material. Abrasive wear-resistance, compression strength, and flexural strength were all found to decrease significantly as heterogeneity of the matrix developed owing to phase composition heterogeneity arising because of dissolution or diffusion of the component fillers in the matrix. A two-factor analysis of variance established that macroheterogeneity (F) was more responsible for abrasive wear resistance than was the concentration (C) of tungsten and carbide in the Fe-W-C and Fe-B-C composites ($\sigma^2_F = 0.22$ and $\sigma^2_C = 0.04$). The empirical model developed makes it possible to predict the mechanical properties of composite materials based on heterogeneity of their matrix with an error that is insignificant when compared with random error at a confidence level of 95 percent. Figures 3; references 11 (Russian).

Electrochemical and Corrosion Ti Behavior With Pd and Cr-Pd Electrospark Coats

937D0115A Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 351-358

[Article by L.P. Korniyenko, A.Ye. Gitlevich, P.A. Topala, G.P. Chernov, R.Kh. Zalavutdinov, G.M. Plavnik, G.M. Khrustaleva, N.D. Tomashov, Physical Chemistry Institute at Russia's Academy of Sciences and Applied Physics Institute at Moldovan Academy of Sciences; UDC 620.197.6:669.295:669.26'.234']

[Abstract] The low productivity of electrospark titanium alloying (EIL) with palladium with the help of compact electrodes which otherwise increases titanium's corrosion resistance by one-to-two orders of magnitude prompted an investigation into the corrosion resistance and electrochemical behavior of VT1-0 titanium with Pd or Cr-Pd coats applied from powders by the electrospark technology in H_2SO_4 solutions. To this end, titanium is alloyed in the air in a Razryad-2M unit. The alloying and coat application procedures are outlined in detail. The characteristics of Ti samples with both types of electrospark coats and their corrosion rates in a 10% solution of H_2SO_4 at a 100° temperature during a 5 h test are summarized, and the Pd, Ti, C, and O concentration distribution in the metallographic section of a nonannealed sample based on an X-ray diffraction microanalysis, the anodic and cathodic potentiodynamic curves of Ti with various electrospark coats, and the behavior of the corrosion potential of Ti with electrospark coats are plotted. The findings confirm the effect of alloying on increasing the corrosion resistance and demonstrate the high efficiency of the process. Electrospark alloying leads to the development of intermetallic Ti and Pd compounds on the surface (Ti_2Pd, etc.) as well as titanium nitrides, oxides, carbides, and oxycarbides. Moreover, Ti displays a tendency toward self-passivation due to the low cathodic discharge reaction overvoltage while its corrosion resistance to sulfuric acid at a 100° temperature increases considerably. Application of powdered Cr-Pd powders in a 9:1 ratio makes it possible to increase the corrosion resistance by almost hundredfold and helps reduce the Pd consumption. Figures 4; tables 1; references 15: 14 Russian, 1 Western.

Electrochemical and Corrosion Behavior of Ti_2Pd and TiPd Intermetallic Compounds and Ti With Electrospark Pd Coats

937D0115B Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 359-367

[Article by L.P. Korniyenko, N.D. Tomashov, G.P. Chernova, Physical Chemistry Institute at Russia's Academy of Sciences; UDC 620.197.6:669.295:669.234]

[Abstract] The effect of the spark discharge energy, alloying duration, and the rate of surface scanning by the electrode tool and additional heat treatment on the quantitative and qualitative composition of the intermetallic Ti-Pd compounds forming on the Ti surface following electrospark alloying is discussed, and an attempt is made to compare the corrosion and electrochemical behavior of Pd-coated Ti and Ti_2Pd and TiPd intermetallic compounds. To this end, Pd coats are manually applied to VT1-0 titanium in an EFI-46A electrospark alloying unit in the air. The coat application procedure is outlined in detail. The cathodic and anodic behavior of the intermetallic compounds and palladium-coated titanium is examined using potentiodynamic curves plotted in a 10% H_2SO_4 solution at a 50 and 100° temperature; for comparison, Ti and Pd potentiodynamic curves are plotted too. The phase composition and corrosion potential and corrosion rate (SK) of Ti with an electrospark Pd coat before and after annealing, Ti-Pd intermetallic compounds, and pure Pd in 10% H_2SO_4 at 100° are summarized, and the dependence of the amount of Ti transferred to the solution from Ti_2Pd, TiPd, and Pd-clad Ti, anodic and cathodic potentiodynamic curves of the above compounds, the dependence of the corrosion rate on the potential, and the dependence of the settling potential of various pairs on their area ratio are plotted. The findings demonstrate that the intermetallic compounds forming on the Ti surface during electrospark alloying with Pd with subsequent annealing are efficient cathodes and serve as titanium passivating agents, thus ensuring the electrochemical protection mechanism, while the settling corrosion potentials of Ti with intermetallic compounds fall within a range which is cathodic for the intermetallic compounds and Pd, so Pd does not pass to the solution under these conditions. The Ti corrosion rate in the passive state is determined by the Ti dissolution rate from the intermetallic compounds and Ti dissolution from exposed areas. Figures 5; tables 1; references 8.

Corrosion Behavior of Y-Doped Mg-Cd Alloys

937D0115C Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 405-408

[Article by V.V. Krasnoyarskiy, L.M. Petrova, Physical Chemistry Institute at Russia's Academy of Sciences; UDC 620.193.01:669.7/8]

[Abstract] The effect of Cd-doping up at a 10% concentration (by mass) whereby the corrosion potential shifts but the corrosion rate remains constant is discussed, and the lack of published data on the effect of the cadmium concentration in Y-Md-Cd ternary alloys on the corrosion potential and rate is noted. The corrosion behavior of Y-doped Mg-Cd alloys is examined in river water under free corrosion conditions and during galvanostatic anodic polarization at 1.5 and 5.0 A/m^2. The metal utilization factor (KPI) is determined by the mass loss and quantity of electricity, the alloying constituent percentage is checked by chemical analysis and by determining the phase composition of each alloy while the cadmium concentration is manipulated within 1.4-2.4% and the yttrium concentration—within a wider range of 0.6-12.2%. The constitution diagram of the Mg-Y-Cd

system and alloy compositions, the dependence of the dissolution rate of Mg alloys with various Cd concentration on the Y concentration during free corrosion and anodic polarization, and the cathodic efficiency of high-purity magnesium and Mg-Y and Mg-Y-Cd alloys after 360 h of anodic polarization are plotted. The free corrosion rate of single-phase alloys is 1.5 higher than that of two-phase alloys. Figures 3; references 7.

Accelerated Electrochemical Method of Testing 06KhN28MDT and 03KhN28MDT Alloy Welded Joint Susceptibility to Intercrystalline Corrosion

937D0115D Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 414-421

[Article by Yu.S. Sidorkina, N.G. Zinchenko, G.P. Bekoyeva, T.V. Mankevich, O.N. Markova, Scientific Production Association of the Scientific Research Institute of Chemical Machine Building; UDC 620.196:620.199:669.018.8]

[Abstract] The length of intercrystalline corrosion (MKK) susceptibility tests of corrosion-resistant steels and alloys under GOST 6032-89 standards prompted the development of an accelerated electrochemical method of testing the intercrystalline corrosion susceptibility of 06KhN28MDT (EI943) and 03KhN28MDT (EP516) alloys on the basis of an electrolyte containing $HCl+CuCl_2 2H_2O$. To this end, the alloy susceptibility to intercrystalline corrosion is determined by the change in the corrosion potential under a drop of electrolyte. The study is carried out using sheet, bar, and pipe samples from 38 commercial smeltings of EI943 and EP516 alloys with a chemical composition pursuant to GOST 5632-72. The samples were tested in a cold state, after heating at 770° with 20 min and 1 h exposure, and in a welded state (by argon arc and electric arc methods). Before recording the potential behavior, the samples were pickled by Krupp's agent at room temperature. The polarization curves of 06KhN28MDT alloys in the original condition and after sensitizing annealing, the element concentration in various sensitized alloy zones, and the potential behavior curves under the electrolyte drop are plotted. For comparison, the outcome of tests carried out by the VU method (GOST 6032-89) are summarized. The results show that alloys EEI943 and EP516 are in a stably passive state at a 0.4 V potential and a 0.6 V solution redox potential. In alloys susceptible to ICC, pitting is observed along the grain boundaries after pickling in Krupp's reagent. The findings obtained by the electrochemical method are consistent with the those obtained by the VU method both in the base metal and in the weld. Altogether, 76 smeltings are tested by the electrochemical method in the original condition, after heating, and in the weld area. Only six out of 91 samples displayed a discrepancy between the results obtained by the proposed method and by the VU procedure. Figures 5; tables 3; references 2.

Increasing Titanium Heat Resistance by Electrospark Alloying

937D0115E Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 505-508

[Article by S.F. Vdovin, Applied Mechanics Institute at the Urals Department of Russia's Academy of Sciences; UDC 620.193.54]

[Abstract] The low efficiency of vibrating electrode tools (VEI) used in electrospark alloying (EIL) and an equally low productivity of multielectrode spinning tools (MVI) used for this purpose prompted a study of ways to protect VT1-0 titanium from oxidation in the air at 600+/-110°. To this end, coats are applied to the surface by both electrospark methods in a Ploskost-3 unit using Al, Cr, and Ni working electrode in the air and Kh20N80 Ni-Cr alloy both in the air and in argon. All tests are carried out in a muffle furnace in crucibles whose mass remained constant during the firing. The testing procedure is outlined in detail. The mean Ti oxidation rates at different time intervals with various coats are summarized. The oxidation behavior of bare VT1-0 titanium and coated metal in the air at a 600° and 8800° temperature is plotted. The findings indicate the the heat resistance of titanium can be increase by electrospark alloying. For this purpose, Al is a cheap and effective material which can be best applied by a multielectrode spinning tool. Extended annealing of titanium with such a coat in the air at 600° improves its subsequent performance. The maximum operating temperature of such treated material is 800°. Figures 2; tables 1; references 3.

Phosphorus-Containing Activator of Thermal Diffusion Steel Saturation With Aluminum

937D0115F Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 508-510

[Article by V.V. Gerasimov, R.T. Porfiryeva, A.V. Peskov, Kazan Civil Engineering Institute; UDC 669.14.018]

[Abstract] The role of activators of diffusion saturation of steels by the powder method, particularly P-containing compounds, is discussed, and it is noted that phosphorus is a sublimating active electron-donor element which can serve as a gas transport agent delivering Al to the protected metal surface. An attempt is made experimentally to verify the possibility of using iron glycerophosphate—a commercially available and cheap product—as an activator of thermal diffusion saturation of steel with Al. To this end, thermal diffusion saturation of carbon steel St.3 with Al is carried out in a mixture of ferroaluminum and iron glycerophosphate. The saturation procedure is described in detail, and the dependence of the corrosion resistance of steel St.3 samples without and with a coat formed by chemical heat treatment in mixtures with various component ratios is plotted. The corrosion resistance is determined by the sample weight gain after tests at a 950° temperature in the air; the coat structure is examined by a DRON-3 X-ray diffraction

analyzer in CuK_α radiation; the study shows that the surface saturation with Al is directly proportionate to the activator quantity. The activating mechanism of glycerophosphate is identified. Figures 2; references 3.

High-Speed Laser-Induced Au Electrodeposition on Model Cu Cathodes With Simple Shape

937D0115G Moscow ZASHCHITA METALLOV in Russian Vol 29 No 3, May-Jun 93 pp 523-525

[Article by Yu.V. Seryanov, L.V. Aravina, Almaz State Scientific Production Enterprise, Saratov; UDC 621.793.14]

[Abstract] A study of laser-stimulated (LS) electrolytic precipitation of gold (*Elektrokhimiya* Vol. 26 No. 7, 1990, p. 888) is continued. The effect of the model Cu cathode shape and dimensions on the process parameters is considered in detail since the problem of local Au deposition on curvilinear surfaces is quite urgent for practical corrosion-preventive gold plating in electronics and jeweler's art. A formula is derived for the radial time distribution of the local gold spots with a given radius, and experiments with high-speed laser-induced Au electrodeposition carried out on rectangular parallelepiped, cylindrical, and spherical cathodes made from vacuum-smelted copper using Pt-plated Ti anodes are described. Electrodeposition is locally stimulated by focusing a laser beam on the end of the parallelepipeds, medial lateral surface of the cylinders, and the sphere's surface in a potentiostatic mode. The dependence of the relative local gold-plated spot radius on the exposure duration and the calculated radial time distribution of the gold thickness on local cathode spots are plotted. A study of the high-speed electrodeposition kinetics demonstrates the possibility of forming local gold deposits on three-dimensional parts at a resolution of approximately three focused laser beam diameter at a deposition rate of about 17 μm/min. An LTN-102 laser is used in the experiment. Figures 2; references 5.

Effect of Hydrogen on Diamond Formation Conditions in High Pressure and Temperature Region

937D0136A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 1, Jan 93 pp 1-5

[Article by M.D. Shalimov, R.N. Ziganshina, M.V. Astakhov, Moscow Steel and Alloys Institute and High Pressure Physics Institute at Russia's Academy of Sciences; UDC 666.232]

[Abstract] Conflicting published data on the effect of hydrogen on the diamond formation process, probably due to the dependence of the growth mechanism on the synthesis parameters, are discussed, and it is speculated that one of the primary functions of atomic hydrogen is to dehydrate and hydrate the seed crystal surface and participate in intermediate reactions, thus accelerating the acetylene or gaseous radical formation. Hydrogen thus favorably affects crystallization during the diamond synthesis from the gaseous phase. To obtain additional information necessary for understanding the mechanism of diamond formation from organic compounds and study the effect of hydrogen on the diamond formation process, certain patterns of diamond synthesis from carbon materials produced by heat treatment under pressure of wood chips (UM-400 and UM01200 under 2.0 GPa at 673 and 1,473K) are studied; in addition, materials produced by degassing the two sets of chips (UM-400d and UM-1200d) at different hydrogen and oxygen concentrations before and after degassing are used. The experiment is conducted in a toroid chamber at pressures of 7.7 and 8.0-9.0 GPa within a 1,800-2,100K temperature range. The results of an X-ray diffraction analysis are presented, and the structural changes the the UM-400 and UM-400d carbon materials during heat treatment at a 8.0-9.0 GPa pressure are summarized. As a result of an addition of Ni to UM-400 containing 3.23% hydrogen by mass, diamond forms only within a 8.0-9.0 GPa pressure range while diamond does not form in the UM-1200-Ni system. The findings show that hydrogen has a negative impact on the catalyst even at a pressure of 8.0-9.0 GPa yet at a 2,100K temperature, a sufficiently high hydrogen concentration in the system ensures the diamond forming process regardless of the catalyst metal presence. Figures 1; tables 2; references 30: 12 Russian, 18 Western.

Effect of Chemical Composition and Microstructure on Mechanical Properties of Cold Rolled Sheet Steel 08kp

937D0137B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 2, Feb 93 pp 45-46

[Article by M.A. Shumilov, D.I. Yaroslavskiy, Ye.N. Kozlova, Ye.D. Poberezhskaya, Mariupol Metallurgical Institute; UDC 669.15-194:621-413]

[Abstract] The high stamped item rejection rate prompted a study of the properties of cold rolled 0.5-2.0 mm thick sheets from steel 08kp made at the Mariupol Integrated Iron and Steel Works for deep drawing. The chemical composition, mechanical properties, and microstructure characteristics of cold rolled sheets are summarized. The ferrite grain, structurally free cementite, and nonmetallic inclusion indices are determined in accordance with state standard requirements. An analysis of steel sheet samples shows that both good and rejected samples have an almost identical chemical composition while the microstructure differs significantly. The significant correlation pairs of the ductility, microstructure, and chemical composition indicators of good and rejected rolled samples are determined. The findings demonstrate that the nonmetallic inclusion and cementite and ferrite grain indices greatly affect the cold rolled steel sheet ductility; the correlation values and signs show that a decrease in the Mn and S concentration in steel should improve the ductility characteristics. Disperse precipitates and crystal lattice defects in ferrite not visible under optical microscope affect the coercive force and have a negative impact on ductility. Tables 3; references 2.

Wear-Resistant Antifriction Chrome-Copper Cast Irons

937D0139A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 4, Apr 93 (manuscript received 5 Dec 91) pp 30-31

[Article by A.A. Zhukov, V.P. Polovinchuk, and V.S. Churkin, Vinnitsa Polytechnic Institute; UDC 669.131.6]

[Abstract] The wear resistance (especially during treatment in thermal cycles), antifriction properties, heat conduction, and machineability of gray cast irons can be increased significantly by alloying them with copper and chrome. Studies have shown that the main reason for these positive effects is the fact that the excess copper in the iron-copper solid solution (more than 0.6-0.7 percent) is released on the interface surfaces and along the grain boundaries. Moreover, in cast irons containing more than 0.1 percent copper, treatment by thermal cycles triggers segregation of the copper onto the interface surfaces and outer surface of the metal. Studies performed on type SCh20 cast iron with up to a 3.5 percent copper content established that cast iron containing 0.8 percent copper and having a hardness of HB 260 is as workable as analogous gray cast iron that does not contain any copper and than has a hardness of HB 200. Auger electron spectroscopy studies performed on specimens of copper-containing cast iron before and after treatment by thermal cycles (500 cycles of heating to 350°C for 15 seconds followed by cooling in air for 15 seconds) revealed that the cast iron had an average copper content of 1.8 percent (by weight) and the solid solution had a 0.6 percent copper content. Prior to treatment by thermal cycles, the copper concentration

near the grain boundaries amounted to 4.2 percent, and that on the machined surface amounted to 0.35 percent. After treatment by thermal cycles, the copper concentrations amounted to 6.3 and 2.8 percent, respectively. The spectroscopy studies thus confirmed that the concentration of copper near the grain boundaries in a 1-μm-diameter segment was 2 to 2.5 times the average concentration in the cast iron and 50 percent lower on the machined surface than in the iron-copper solid solution. The latter result was taken as confirmation of the microtransfer of copper atoms from the machined surface to the cutter during lathing. Adding chrome to copper-containing gray cast iron was found to give it a wear-resistant composite structure with stable mottling. Figures 3; references 7: 6 Russian, 1 Western.

Development of a Variable-Structure Mathematical Model To Analyze and Predict a Blast Furnace's Operating Indicators Based on Accountability Data

937D0139C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 4, Apr 93 (manuscript received 30 Mar 92) pp 51-55

[Article by L.Yu. Gileva, Yu.G. Yaroshenko, S.A. Zagaynov, and Ye.L. Sukhanov, Ural Polytechnic Institute; UDC 669.162.2.001.57]

[Abstract] Researchers at the Ural Polytechnic Institute have developed an approach to analyzing and predicting a blast furnace's operating indicators by using a mathematical model with a variable structure. The specific model structure to be used in any given analysis is selected during a process of adapting it to the array of accountability data regarding the operating indicators of the given blast furnace in the base period. The logical scheme on which the modeling process is based is in the form of a rank sequence for evaluating the computation results. This sequence makes it possible to determine the most reliable information regarding the blast furnace's operation in the base period and to select that equation system that uses this information and independent variables. The proposed mathematical model's use is illustrated by way of the example of determining the thermal balance in the lower region of a blast furnace in base and comparison periods. In the equation series presented, all available data regarding the following are used: amount of cast iron smelted, composition of the throat gas, composition of the burden, and parameters of the combined-blasting process. The proposed model was used to analyze the operation of the blast furnaces at the Magnitogorsk, Novolipetsk, and Western Siberia metallurgy combines in 1987-1990. The results were tentatively divided into two groups: The two groups included results with a range in specific coke consumption up to and greater than +/-10 kilograms per tonne of cast iron, respectively. The model estimates did not deviate from the accountability data by more than 20 percent in 70 of cases in the first group and 36 percent of cases in the second group. The lower percentage of coincidence in the latter case was attributed to computation errors linked to the use of a linearized blast process model and dependent upon the number of input parameters altered and their values. Figures 2; references 4 (Russian).

Effect of Additional Tempering on the Properties of Rotor Steel

937D0140D Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 5, May 93 (manuscript received 21 Oct 91) pp 53-54

[Article by V.P. Tarabanova, L.D. Mishchenko, and S.S. Dyachenko, Kharkov Automobile and Highway Institute; UDC 669.15:620.186.5]

[Abstract] A study examined the effect of additional tempering on selected properties (strength, plasticity, and fracture toughness of EI-415 rotor steel. The steel had the following starting composition (%): C, 0.23; Si, 0.29; Mn, 0.48; S, 0.014; P, 0.008; Cr, 2.71; Ni, 0.13; Mo, 0.48; V, 0.70; and W, 0.41. The steel was subjected to isothermal annealing at 990°C for 6 hours, cooled to 700°C, held for 30 hours, and then cooled while still in the furnace. It was then normalized at 1,040-1,050°C and cooled in air, hardened at 990-1,010°C for 5 hours and cooled in oil, and tempered at 680-700°C and cooled in the pit for 18 hours. Studies of a forging produced from the steel established that additional tempering increases their fracture toughness while only slightly reducing their strength characteristics. A tempering temperature of 700°C (holding for 12 hours) reduces ultimate strength by only 4 percent while increasing fracture toughness by 40 percent. A tempering temperature of 730°C (holding for 12 hours) reduces ultimate strength by about 10 percent while increasing fracture toughness by about 80 percent. Additional annealing had analogous effects on the properties of other forgings made of rotor steel as well. These effects of additional tempering were attributed to carbide formation processes and alteration of the state of the rotor steel's matrix. Metallography and roentgenographic studies confirmed that additional tempering causes the metal matrix to be in a higher state of equilibrium and thus makes fracture toughness the property most sensitive to changes in tempering temperature. Additional annealing was also found to increase plasticity by about 15 percent. Figures 2.

Automated System To Study and Control Converter Melting Blasting Regimens

937D0140F Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 5, May 93 (manuscript received 17 Apr 92) pp 76-78

[Article by S.P. Mochalov, V.M. Tolstenev, Ye.I. Liverts, S.V. Klemashev, and V.G. Korotkikh, Siberian Metallurgy Institute; UDC 669.184:65.011.56]

[Abstract] Work to develop an automated system for researching and controlling blasting regimens used in converter melting is in progress. The system's lower level of blasting regimen control includes the following components: controller; unit interface modules; unit to specify control actions; alarm unit; circuits controlling the drives of the oxygen control valve and the vertical movement of the tuyere; sensors measuring the oxygen flow rate and position of the tuyere; and actuator of the tuyere's vertical movement and oxygen flow control valve. The system performs the following functions: process instructions regarding the tuyere's position and oxygen flow rate; control the tuyere's position and oxygen flow rate based on scanning programs; control the tuyere's position and oxygen flow rate based on programs of arbitrary type; automatically lower the tuyere into its working position and switch on the oxygen for blasting; automatically raise the tuyere and switch off the oxygen; execute emergency lifts of the tuyere when the blocking system is activated; and issue signals regarding the control object's status. The algorithm developed to control the system's operation permits manual or automatic control. The system has a setup mode and three operating modes (remote, semiautomatic, and automatic). The algorithm developed to condition the signals controlling the drives that move the tuyere and regulate the oxygen control valve was developed on the basis of an analysis of the following control object characteristics: maximum and minimum speed of the oxygen tuyere; inertia, insensitivity zone, acceleration time, and shutdown time of the tuyere drive; time required for complete opening (closure) of the oxygen valve; inertia, insensitivity zone, and nonlinearity of the characteristics of the oxygen valve; and delay and noise immunity in the information-receiving channels. The system includes the following software controlling the controller's and interfaces' operation: a real-time supervisor; subroutine operations based on interrupts and operations and computation subroutines; initial loading and initialization subroutines; and service utilities. In 1989, the new system was implemented in the No. 2 oxygen-converter shop at the Western Siberia Metallurgy Combine. Pilot operation of the new system indicated that it processes instructions regarding the tuyere's position with a precision of 0.02 m, determines errors of 1 m in 6 seconds, controls the oxygen flow rate with a precision of 20 m^3/min, requires 7 seconds for emergency raising of the tuyere from its operating position (+1 m) to the converter's outlet (4.8 m), and requires 4 seconds to close the valve completely. A PC-based tool kit has also been developed for use in developing software for the system and debugging and testing it. Figures 2; references 2 (Russian).

Heat Confinement with Rolled Fibrous Materials Rated for Temperatures Up to 1350°C bat[S.Ya. Tsypin, V.V. Martynenko, et al.; OGNEUPORY, Feb 93]

937D0118C Moscow OGNEUPORY in Russian No 2, Feb 93 pp 33-35

[Article by S.Ya. Tsypin and V.V. Martynenko, Ukrainian State Scientific Research Institute of Refractory Materials, Yu.G. Kalenskiy and I.I. Shakhov, All-Russian Scientific Research Institute of Thermal Design, V.M. Kovylov and Yu.I. Tomilin, Sukholozhskiy Refractory Materials Plant, and B.A. Fomenko, Oskol Electrometallurgical Combine; UDC 666.762.1-486: 621.783.2]

[Abstract] Refractory fibrous materials used in the lining of furnaces and other heat generating equipment, to prevent escape of heat and thus ensure maximum fuel economy, are tentatively classified into "soft" ones and "stiff" ones. The first group includes rolled materials characterized by an elasticity sufficiently to make them suitable for flat and curved lining layers. Most resistant to heat with a tolerable shrinkage at temperatures up to 1200°C and to mechanical action of gas streams flowing at velocities up to 10 m/s are mullite-silica MKRV-200 "voylok" and MKRF-100 "fetr" felts (51-52 % Al_2O_3), backed by mullite-silica MKRR-130 mineral wool serving as thermal insulation. The felt and the mineral wool are pinned together to a shield plate, on the cold side, by an array of steel pegs welded to that plate. On the hot side the pegs are inserted into anchors made of fireclay-kaolin or high-alumina ceramic by the semi-dry molding process and pressed into the felt. Each anchor consists of a straight bushing for a peg and a conical washer at the base, the washers being made of either heat-resistant steel for temperatures up to 1150°C or of ceramic for still higher temperatures. Using longer bushing allows using pegs made of less heat-resistant steel. The lining is tightened in place by turning these washers. The anchors in the vault lining of the fuel reformer in the Oskol plant are imported ones, made of a ceramic material with a 1600°C rating. A domestic analog of such an anchor has been designed with a material consisting of alumina, quarts sand, and kaolin. For temperatures up to 1350°C, moreover, there has been developed a new felt material containing 57.2 % Al_2O_3 (38.6 % SiO_2, 0.8 % Fe_2O_3, 0.7 % CaO, 0.2 % MgO, 0.2 % Na_2O + K_2O). This material, originally produced in the form of a 25 mm thick strips, has an apparent density of 0.1 g/cm^3 and a steady-state thermal conductivity which increases from 0.11 W/(m.K) at 350°C to 0.28 W/(m.K) at 600°C. In order to ensure a low thermal conductivity at 1200-1300°C and a high resistance to gas stream action, its apparent density must be increased to at least 0.15 g/cm^3. Its shrinkage is only 6.8-7.4 % at 1300°C and 9.3-12.0 % at 1400°C, thus much smaller than that of MKRV-200 and MKRF-100 felts. A double-layer lining suitable for temperatures up to 1350°C has been constructed using a 75 mm thick layer of the more compact new felt material and a 150 mm thick layer of more compact MKRR-130 fibrous thermal insulation. Figures 2; tables 1; references 4.

Self-Propagating High-Temperature Synthesis and Technologies Based on It

937D0120C Moscow OGNEUPORY in Russian No 4, Apr 93 pp 21-24

[Article by V.I. Sumin Central Scientific Research Institute of Materials Science, and Yu.N.

[Abstract] Self-propagating synthesis, which involves burning but not heating, offers the advantages of low energy consumption and high productivity along with high product purity not attainable by most conventional technological processes. New technologies have been developed on the basis of such a synthesis for production of refractory oxides and oxygen-free compounds, in some cases with no waste. The suitability of such a synthesis for their production is determined not only by the variety of raw ingredients but also by the not otherwise feasible specific combinations of reactants and products. Its three basic applications are: 1) powder technology where the combustion temperature of the raw material is lower than the melting point of the product; 2) technology which combines synthesis and forming of its product, where the two temperatures are very close; 3) technology of refractories and other cast materials, where the melting point of the product is lower than the combustion temperature of the raw material. Besides the synthesis, common to all three technologies are the operations of batching and mixing followed, if necessary, by briquetting of the mixture. All operations can be automated and integrated into one continuous process. A review of open-crucible (with chemical igniter), vacuum, high-pressure, and cryogenic powder technology variants is followed by an analysis of the subsequent product manufacturing process, this analysis being based on known physical conditions and energy relations applicable to porous materials such as most of those produced by self- propagating high-temperature synthesis. Metallothermic processes are of interest, especially for production of cast refractories: 1) out-of-furnace heating (the heat of reaction being sufficient for reducing and melting the processed material; 2) heating in electric furnace;, 3) vacuum heating (the reaction taking place under vacuum, owing to high volatility of some substances involved). Metallothermy is particularly expedient for production of refractory slags by self-propagating high-temperature synthesis, typically: $Cr_2O_3 + 3Mg \rightarrow 3MgO + 2Cr$ $Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$ $3MnO_2 + 4Al \rightarrow 2Al_2O_3 + 3Mn$ $2Fe_2O_3 + 3Si \rightarrow 3SiO_2 + 4Fe$ Already more than 400 different refractory materials have been produced by these technologies, experimental and pilot-production stages for self- propagating high-temperature synthesis having been built by the Interdepartmental Scientific-Technical "Termosintez (Thermosynthesis)" Association. Figures 2; references 4.

Characteristics of Structural Oxide Ceramic Made from Mechanically Comminuted Powders

937D0118A Moscow OGNEUPORY in Russian No 2, Feb 93 pp 20-23

[Article by V.V. Grishayev and V.I. Tostanovskiy, All-Russian Scientific Research and Manufacturing Engineering Institute of Electric Machinery; UDC 666.762.1+666.762.53/:621.762.5]

[Abstract] Structural ceramic materials were produced experimentally from powders of chemically pure or extra pure aluminum oxide and zirconium oxide or zirconium oxide with yttrium oxide. The powders were first mechanically comminuted to a given grain size distribution in a TEMA vibratory abrader made of tungsten carbide and then, after having been combined in a RETCH mixer, further comminuted as a mixture in a ball mill made of copper with corundum lining. The grain size distribution was monitored with a Fritch Analizette-22 laser-type analyzer. The phase compositions of powders and ceramics were determined by conventional x-ray phase and chemical analyses. Sintering was done in reverberatory furnaces: in an air furnace at 1400-1800°C and in a vacuum furnace at 1500- 1700°C. Some specimens were afterwards additionally compacted by isostatic hot pressing at 1400°C in an argon atmosphere under pressure rising to 200 MPa and holding under maximum pressure some for 1 h and some for 2 h. Three powder mixtures were thus sintered: 1) 58.2 wt.% Al_2O_3 + 41.8 wt.% ZrO_2 (4 mol.% Y_2O_3); 2) 54.5 wt.% Al_2O_3 + 45.5 wt.% ZrO_2 (8.8 mol.% Y_2O_3); 3) 52.0 wt.% Al_2O_3 + 48 wt.% ZrO_2 (12.6 mol.% Y_2O_3). The sintering process and its product were found to depend largely on the sintering temperature and on the powder dispersion. The ceramic materials were first tested for density, porosity, and shrinkage. Their microstructure was examined under a Jeol JMS-840 electron microscope. Their mechanical strength was measured on 50 mm long bars 3.5x5.0 mm^2 in cross-section, other properties were measured on 70 mm long bars 5.0x6.5 mm^2 in cross-section. Two kinds of specimens were tested: 1) specimens produced by straight isostatic cold pressing under a pressure of about 300 MPa, 2) specimens produced by uniaxial compression with 5 % polyvinyl alcohol as binder under a pressure of 300 MPa and subsequent supplementary isostatic cold pressing. Isostatic cold pressing under high pressure and subsequent isostatic hot pressing were found to facilitate production of nonporous ceramics with grains within the up to 1.0 μm size fraction. Finer powders could be sintered at lower temperature. A powder mixture of 47.2 wt.% Al_2O_3 + 52.8 wt.% ZrO_2 (4.8 mol.% Y_2O_3 with grains of the 0.2-0.3 μm size fraction was prepared for a further study of the sintering process. Ceramics having a density above 90 % of the theoretical one could already be produced by sintering at only 1400°C. There were also produced ceramics having a flexural strength within the 700- 750 N/mm^2 range at room temperature and about 500 N/mm^2 at 1000°C. Figures 4; references 3.

Optimizing Composition and Properties of Plastic Materials Used in Manufacture of SiC Products

937D0120A Moscow OGNEUPORY in Russian No 4, Apr 93 pp 3-6

[Article by A.S. Rabinovich, S.V. Kazakov, and L.L. Vanicheva, All-Russian Institute of Refractory Materials; UDC 666.762.852.017]

[Abstract] An experimental study of the composite "polycrystalline SiC (filler) + organic resin (binder)" was made, its aim being to obtain a resin with optimum composition and properties for manufacture of SiC products. As the binder was used phenol formaldehyde, this resin being not only an excellent plasticizer of SiC grains but also yielding a dense coke residue upon its thermal decomposition during the subsequent technological processes. The mass fraction of coke residue is being increased and the plasticizing capability thus enhanced by addition of industrial carbon to the resin, silicon being also added as one of the carbide-forming elements. Thermogravimetric tests and differential thermal analysis were performed on carbon-bakelite, carbon-SiC, and bakelite-SiC mixtures. Microstructural examination of hardened briquettes containing 70-90 % SiC (remainder Si and carbon) was performed under a reflecting microscope. On the basis of this examination have been calculated first the porosity of hardened briquettes and the ratio of apparent to true filler densities, then the ratio of binder to filler (SiC) mass fractions in the perfect case of zero porosity. This ratio has been shown to depend on the mechanism of final structurization during siliciding heat treatment (1900-2300°C). A plasticizer yielding as much as 94 % SiC in the final product has been successfully obtained by reduction of the molding pressure, the product having not only excellent mechanical properties but also a high electrical resistivity: flexural strength 37 N/mm^2 and 0.180 Ω.cm (C_{bind}/C_{fill}= 0.18 with rubber:bakelite= 3:1 in binder, molded under a pressure of 3.5 MPa). Figures 2; tables 2; references 3.

Technology of Unidirectionally Nonhomogeneous Light-Weight Refractory Material

937D0118B Moscow OGNEUPORY in Russian No 2, Feb 93 pp 27-29

[Article by V.N. Sokov, Moscow Institute of Construction Engineering, B.A. Dzhandarbekov, Kazan Institute of Chemical Technology, V.A. Naumenko and Talakuyev, Podolsk Refractory Products Manufacturing Plant; UDC 666.762.15-127]

[Abstract] A technology has been developed for improving products made from light-weight refractory materials by redistributing their properties (density - compressive strength - thermal conductivity) so as to form a unidirectionally nonhomogeneous structure of the triple-layer kind without change of their composition

and dimensions. This technology was applied to products made from mixtures of 80 % Podolsk kyanite-sillimanite concentrate + 20 % Druzhkov clay, to which 8-12 % granular polystyrene of the < 0.5 mm grain size fraction after it had been partially frothed in boiling water for 8 min. A given amount of polystyrene was fed into a paddle-wheel stirrer containing water, whereupon the two refractory components were added and the entire charge was mixed for 6-7 min. The slurry, with a 45-50 % moisture content, was poured into a rigid mold with perforated lid and bottom for compaction on two opposite sides under heat. In a single technological process involving bidirectional moisture mass transfer and regulated filtration the self-packing mass distributed itself so as make its density vary linearly from minimum on the inside boundary to maximum at the outside boundary of each of the two compact surface layers. Electric heating was done with a 50 Hz alternating current, polystyrene becoming completely sintered at some temperature 80°C and excess pressure then building up in the mold. Best results were obtained by heating the slurry in three stages: 1) heating it to 85-95°C in the center and to 65-70°C at the surface within 4-5 min, then shutting off the heat for 4-5 min so as to allow cooling to 80-85°C in the center and to 50-55°C at the surface; 2) heating it to 110-115°C in the center and to 80-85°C at the surface within 5-6 min, then shutting off the heat for 6-7 min so as to allow cooling to 100-105°C in the center and to 60-65°C at the surface: the polystyrene beginning to become sintered in the two opposite surface layers and the pressure in the slurry rising to about 0.2 MPa; 3) heating it to 120-125°C in the center and to 95-100°C at the surface within 12-15 min: all the polystyrene in the entire slurry becoming completely sintered and the pressure in the mold rising to 0.3 MPa. During cooling after this last stage both the pressure in the mold and the rate of moisture ejection decreased gradually (a 10-15 % residual moisture content remaining in the nonhomogeneous casting), while continued outward migration of fine-disperse particles from the middle layers ensured final formation of dense surface layers. Figures 1; tables 1.

Effect of Annealing in Vacuum or in Nitrogen on Structure and Strength of Porous Si_3N_4-Base Materials

937D0120B Moscow OGNEUPORY in Russian No 4, Apr 93 pp 6-8

[Article by V.N. Antsiferov, V.G. Gilev, A.G. Lanin, O.N. Yerin, V.N. Turchin, and S.V. Leonov; UDC 666.762.93.046.4]

[Abstract] An experimental study of porous Si_3N_4 ceramics for thermally-insulating structural materials was made concerning the temperature dependence of their mechanical and thermal properties after lengthy high-temperature annealing in vacuum or in a protective nitrogen atmosphere, a nitrogen atmosphere preventing thermal dissociation of $Si_3N_4 \rightarrow 3Si + 2_2$. Synthesis of Si_3N_4 was achieved by sintering a slurry of pure silicon powder with an organic binder and special additives in an atmosphere of commercially pure nitrogen in a non-flow furnace with a graphite heater at 1350 C for 1.5-2.0 h and at 1600°C for 1.0-1.5 h. The phase composition of the compacts was determined in an x-ray diffractometer, the volume ratio of α-Si_3N_4 to β-Si_3N_4 varying over the 0.5-0.8 range and the volume fraction of free Si not exceeding 1 %. The slurry had been formed mechanically into 0.003-0.05 mm thick and 1.0-1.5 mm wide bars. These were molded together in a cylindrical cavity under various pressures ranging from 0.5 kPa to 5.0 kPa pressures and at various heating rates, with the temperature of the plunger being held constant within (150±3)°C. The porosity of thus produced ceramic preforms varied over the 59.3-68.0 % range. These were cut, with a diamond tool, into prismatic test specimens 60 mm long and 6 mm square in cross-section. Density was measured by hydrostatic weighing, the surface of the specimens having been covered with with a thin paraffin coating. Flexural strength and thermal conductivity before and after high-temperature annealing in a nitrogen atmosphere at 1350°C for 10 h or under a vacuum of 15 mPa first at 800°C and then at 1350 C were measured in each case at a strain rate of 0.001 s^{-1} and at temperatures covering the 20-1400 C range. Annealing in a nitrogen atmosphere at 1350 C or in vacuum at 800 was found not to have altered the structure and the properties of the materials. Annealing them in vacuum at 1350 C was found to lower both their density and thermal conductivity by a factor of 2 and their flexural strength by a factor ranging from 2 to 4. Figures 4; references 8

On Mechanism of Diamond Formation With Gaseous Phase Participation in Area of High Pressures and Temperatures

937D0138A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 3, Mar 93 pp 15-18

[Article by M.V. Astakhov, R.N. Ziganshina, M.D. Shalimov, Moscow Steel and Alloys Institute and High Pressure Physics Institute at Russia's Academy of Sciences; UDC 666.232]

[Abstract] The lack of published data on the mechanism of diamond production by synthesis from organic compounds under a pressure of 8.0-9.0 GPa at a 2,000-2,100K temperature which was first proposed and developed at the High Pressure Physics Institute at Russia's Academy of Sciences (IFVD) and makes it possible to synthesize quality diamond crystals at even lower temperatures and pressures prompted a review of the mechanism of diamond formation with the gaseous phase participation at high temperatures and pressures on the basis of numerous published sources. It is speculated that the gaseous phase ensures carbon transport to the diamond nuclei developing by the martensitic mechanism leading to their growth to above-critical size during synthesis. The role of gaseous elements, primarily oxygen and hydrogen, is discussed and an attempt to

verify experimentally this diamond growth mechanism in the thermodynamic stability region is described. The effect of oxygen and hydrogen is examined using a carbon material produced by heat treatment of wood under pressure (TBO) at temperatures of 700 and 1,500K and a pressure of 2.0 GPa. The possibility of oxygen participation is studied in a system consisting of MGOSCh graphite and oxides of noncatalytic metals; based on the proposed mechanism, diamonds initially produced by the detonation method (DAG and UDA) were additionally grown from 10-200 nm to 2-4 μm. The findings make it possible to establish that an 8.0-9.0 GPa pressure increases the probability of diamond nucleation due to a drop in the critical radius. The need to increase the temperature to 2,100K is due to a combination of thermodynamic and kinetic diamond nucleation conditions and chemical reactions in the gaseous phase. Figures 1; references 34: 11 Russian, 23 Western.

Optimizing the Properties of High-Temperature Superconducting Materials

937D0139B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 4, Apr 93 (manuscript received 11 Dec 91) pp 40-44

[Article by A.S. Rykov and A.V. Dukov, Moscow Steels and Alloys Institute; UDC 669.046:62-503.5]

[Abstract] An algorithm has been proposed for optimizing the properties of high-temperature superconducting ceramic materials. The algorithm was developed for the case of a ceramic material separated by a plane *AB* from the vacuum surrounding it. A twin defect, i.e., a defect in the ceramic material's crystal structure, was assumed to be located a distan c of *D* from the plane *AB*, and this defect was associated with the occurrence of superconductivity at high temperatures (on the order of 90 K). The optimization problem was formalized by constructing a phase diagram in the coordinates I and T (magnetic field intensity and temperature, respectively) and a phase diagram under conditions of the presence of a twinning plane. A Ginsburg-Landau problem was formulated and solved. The proposed optimization algorithm was based on the idea of the sliding tolerance method. An algorithm with a deformable complex from the class of controlled direct-search methods was selected as the basic minimization algorithm. The proposed 18-step algorithm is intended for use in constructing phase diagrams to produce superconducting materials with desired properties. Figures 3; references 2 (Russian).

Synthesis of Diamonds in Graphite-Metal Oxide Systems at High Pressures and Temperatures

937D0140A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 5, May 93 (manuscript received 14 Feb 92) pp 1-3

[Article by M.D. Shalimov, R.N. Ziganshina, and S.N. Tarasov, High-Pressure Physics Institute, Russian Academy of Sciences; UDC 666.232]

[Abstract] A study examined the mechanism of the effect of nontraditional catalysts and oxides on the graphite-to-diamond phase transformation. CuO, MoO_3, and Al_2O_3 served as the nontraditional catalysts, and type MGOSCh graphite and metal oxide in amounts corresponding to oxygen concentrations of 0.1 to 15 percent of the carbon's total weight served as the reaction mixture. All of the experiments were conducted in a "toroid"-type high-pressure chamber with a container made of lithographic stone. A reaction screen made of Al_2O_3 and 20 percent BN was used to prevent the material of the container from penetrating the reaction zone during the synthesis process. The diamond synthesis experiments were performed at pressures ranging from 7.0 to 9.0 GPa and temperatures ranging from 1,500 to 2,200 K. In all of the experiments, the thermobaric treatment of the reaction mixture lasted for 60 seconds. In all of the systems studied with the exception of the system graphite-Al_2O_3, variously shaped diamond crystals as large as 60 μm in size were produced at pressures of 8.5 to 9.0 GPa and a temperature of 2,100 K. According to spectral analysis, the diamonds' total impurity content after the synthesis process did not exceed 0.1 percent. The various reaction mixtures were subjected to x-ray phase analysis after thermobaric treatment. According to the analysis, the simplest chemical transformations occurs in the system CuO-graphite: Only diamond and metallic copper were found to be present in the reaction mixture, thus confirming the reduction of the copper oxide. Experiments involving a graphite-CuO mixture with 6.0 and 10.0 percent (by weight) oxygen at pressures of 8.5-9.0 GPa and various temperatures followed by hardening demonstrated that reduction of the copper oxide begins at 900 K and is virtually complete by 1,500 K. A more complex pattern was observed in the remaining systems studied: as the diamonds were synthesized, the metal oxides were reduced only to their lowest oxides, carbides, and carboxides. The absence of metal oxide reduction processes in the system graphite-Al_2O_3 caused the researchers to hypothesize a diamond growth mechanism in the vicinity of its thermodynamic stability that is linked to the participation of carbon oxides rather than to the appearance of catalytic properties of reduced metals under the synthesis conditions. This hypothesis was confirmed by experimental data obtained during a study of the dependence of the degree of transformation of graphite into diamond on the reaction mixture's oxygen content. The maximum degree of graphite-to-diamond transformation (about 95 percent) was thus obtained when copper oxide was added to graphite. In the other systems studied, a transformation rate of about 65-75 percent was achieved. This lower transformation rate was attributed to the carbide formation processes that occur when MoO_3, WO_3, and TiO_2 are reduced. Figures 3; references 7: 1 Russian, 6 Western.

Effect of Long Hydrogen Storage on Properties of High-Pressure Tanks

937D0121D Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 93 pp 29-31

[Article by T.A. Beylinova, I.A. Storozhenko, Ye.N. Vasilenko, A.F. Dudnik, and V.N. Feyglin, All-Union (?) Scientific Research Institute of Pipe Industry; UDC 621.774-464:546.11]

[Abstract] Three refueling gas tanks made from seamless rolled tubes of martensitic 38CrN, chromium steel (400 dm^3 capacity) 35CrNi3MoVN, Ni-Cr steel (400 dm^3 capacity), and 45 plain carbon steel (40 dm^3 capacity) were examined after service under hydrogen pressure of 32 MPa (3-5-8 yrs), 20 MPa (5-8-15 yrs), and 15 MPa (5-27-53 yrs) respectively. The alloy steels had been quenched from 870°C and then reheated for high-temperature tempering. The plain carbon steel had been normalized from 870°C. The amount of hydrogen absorbed by the steels over the given service periods and its effect on the steel and tank characteristics were evaluated on the basis of tests performed on specimens cut from the cylindrical tank segments. Hydrogenation of steel was found to have taken place, to a degree dependent on the its mechanical strength and on its alloy content as well as on the service pressure. The reliability of tanks was estimated on the basis of the critical embrittlement temperatures read on cold-shortness curves covering the 20-(-100)°C range as well as on the basis of the sensitivity to notching under static and dynamic loads. A comparison with tanks carrying compressed air for as long periods of time revealed no unfavorable effect of hydrogen on the reliability of these tanks in service. An exception were specimens of the two alloy steels loaded in tension at a rate 200 times slower than according to standard specification. In this case an unfavorable effect was detected only in the characteristics most sensitive to hydrogen embrittlement, but no formation of cracks and pores. Figures 3; tables 3.

Structure of Surface Layers and Wear Resistance of Quenched 50Mn Steel after Nonabrasive Antifriction Finishing Treatment

937D0121B Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 93 pp 5-9

[Article by L.M. Rybakova, L.I. Kuksenova, and Yu.A. Nazarov, Institute of Machine Science at Russian Academy of Sciences; UDC 669.14.018.298:620.178.16]

[Abstract] An experimental study of sleeve-ring friction pairs was made, sleeves of quenched 50Mn steel having been subjected to nonabrasive antifriction finishing treatment by brass plating after having been heated by a high-frequency electric current. For a comparative evaluation, some sleeves were only quenched after being heated in the same manner. Each sleeve was tested in a 77MT-1 machine in an oil bath for sliding friction during reciprocating motion at an average velocity of 0.1 m/s under a pressure of 30 MPa against a self-aligning stationary chromium-plated ring of cast iron, which transmitted that pressure to he sleeve. After successive intervals a sleeve was washed with a benzin + acetone mixture and then dried in air prior to being weighed for measurement of the loss of mass, for subsequent calculation of the wear rate and the linear wear. The surface structure and microgeometry were examined by a special method with a sliding x-ray beam, enabling a nondestructive layer-by-layer examination of the friction-affected zone, and using CoK_{α}-radiation reflected by 0.5-7.5 μm thick layers or microphotography. The results indicate that, under the given conditions, the rates of wear of 50Mn steel only quenched and that of 50Mn steel also brass-plated after having been heated do not differ much. During run-in, however, brass-plated 50Mn steel was found to wear more, the brass coat being evidently destroyed in the process. An evaluation of the set of tribological parameters characterizing the quality of this finishing treatment identifies this as the mechanism which after the run-in period limits the effectiveness of that nonabrasive antifriction finishing treatment. Figures 6; references 14.

Effect of Thermoplastic Treatment on Mechanical Properties of 09Mn2Si Steel

937D0121A Moscow METALLOVEDENIYE I TERMICHESKYA OBRABOTKA METALLOV in Russian No 3, Mar 93 pp 2-3

[Article by S.A. Kotunova and A.G. Ksenofontov, Moscow State Technical School imeni N.E. Bauman; UDC 669.14.018.98:621.785.79]

[Abstract] In an experimental study concerning the effect of high- temperature thermoplastic treatment of hot-rolled 09Mn2Si steel on its mechanical properties and particularly their dependence on the post- treatment cooling rate, specimens of this steel were subjected to three different modes of such a treatment by cyclic alternating flexure and subsequent cooling. The first mode treatment (A) included austenization at 1050°C, cyclic plastic deformation beginning at 970°, and was followed by cooling at a rate lower than 60°C/s. The steel was then found to consist of ferrite and pearlite, just as initially after hot rolling. The second mode of treatment (B) included austenization at 1070°C, cyclic plastic deformation beginning at 990°C, followed by cooling at a rate of approximately 100°C. The steel was then found to consist of ferrite and bainite (more ferrite than bainite). The third mode of treatment (C) included austenization at 1050°, cyclic plastic deformation beginning at 970°C, followed by cooling at a rate higher than 150°C. The steel was found to consist of bainite and ferrite (more bainite than ferrite). Treatments A and B had increased the impact strength of this steel appreciably. Increasing the cooling rate from 100°C to above 150°C (treatments B and C) had increased its ultimate strength and 0.2-% yield strength appreciably, while correspondingly decreasing not only the percentage elongation and the percentage area reduction but also the impact strength. Figures 1; tables 1; references 3.

Effect of Molybdenum on Properties of Cr-Ni-Mo-V Steels

937D0121C Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 93 pp 16-18

[Article by I.A. Borisov, Scientific-Industrial Association Central Scientific Research Institute of Machine Building Technology; UDC 669.14.018.298]

[Abstract] The effect of adding molybdenum to Cr-Ni-V steels was studied experimentally on specimens from four ladles of 25Cr2Ni2V steel (2.0-2.2 % Cr, 1.9-2.1 % Ni, 0.05-0.07 % V, 0.23 % C, 0.30-0.34 % Si, 0.26-0.30 % Mn) with no molybdenum and 0.29 % Mo, 0.67 % Mo, 1.05 % Mo respectively. Ingots weighing 50 kg were forged into bars 30x30 mm^2 in cross-section and these were then annealed according to standard procedure. They were subsequently examined for the effect of molybdenum on the reversible $\alpha \rightarrow \gamma$ transformation and on the austenite grain growth as well as on the structure and the properties after cooling from the Ac_3 temperature at rates from 10°C/h to 10-10,800°C/h. Molybdenum was found to raise the Ac_3 temperature from 800°C (no molybdenum) to 820°C (1.05 % Mo). The results of high-temperature metallographic examination indicate that addition of molybdenum slows down the austenite grain growth. The results of thermomagnetic analysis indicate that molybdenum increases the stability of supercooled austenite. Cooling at a rate of 10,800°C/h prevented pearlite transformation in all four four steels, but addition of molybdenum lowered the M_s temperature and narrowed the temperature range of the austenitic transformation. A chemical analysis of the precipitated carbide revealed that molybdenum had replaced iron and chromium from this phase, the presence molybdenum having also accelerated formation of special carbides. An x-ray structural analysis revealed Mo_7C_3 and Mo_2C carbides along with M_3C carbides of other metals, but a substantial amount of Mo_2C carbide only in steel with 1.05 % Mo. Cooling the steel without molybdenum at a rate of 1800°C/h was attended by decay of about 50 % austenite austenite within the temperature range of pearlitic transformation and subsequent intermediate transformation beginning at 470°C. Cooling the steel with 0.29 % Mo at this rate was attended by decay of only 10 % austenite and subsequent intermediate transformation beginning at 440°C. Addition of 0.67-1.05 % Mo prevented pearlitic transformation at this cooling rate altogether and shifted the temperature range of intermediate transformation downward. The results of mechanical tests indicate that molybdenum increases both tensile and impact strengths of the steel, appreciably when the latter has been cooled fast and much less when it has been cooled slowly at rates down to 10°C. Figures 4; tables 1; references 3.

Nitrogen Alloying of Liquid Cr-Ni Steel From Gaseous Phase in Hyperbaric Plasma Reactor

937D0136B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 1, Jan 93 pp 29-33

[Article by J. Siwka, J. Jowsa, M. Rozpondek, St. Tochowicz, Czestochowa Polytechnic Institute, Poland; UDC 66.046.516]

[Abstract] The increasingly stringent requirements imposed by the users and developers on steels, the favorable effect of nitrogen on the quality of specialty steels, and the importance of ensuring chemical homogeneity and metallurgical purity of the material necessitated the development of new nitrogen alloying methods in place of classical techniques whereby nitrogen is added to liquid metal with alloys of Mn, Cr, V, and Si and $CaCN_2$ and Si_3N_4. The possibility of nitrogen alloying of liquid classical austenitic steel 18/8 with a reduced Ni concentration from activated low-temperature plasma with simultaneous reduction metal refining is investigated assuming that the use of low-temperature plasma with a reaction system sealing creates the conditions for realizing a new process of nitrogen introduction to liquid steel where nitrogen is present in the molecular, atomic, and ionic form while these particles' pressure may be controlled within a broad range. The experiment is carried out in an airtight plasma reactor using physically and chemically homogeneous burden. The alloying conditions and the chemical composition of the steel produced in the airtight plasma reactor during pilot smeltings are summarized. The behavior of the nitrogen concentration in steel 0H17AN6 in the course of remelting in the airtight reactor during refining is plotted. The findings may be used as the basis for developing a modern plasma-based method of making austenitic steel with a high nitrogen concentration. The problem is solved by theoretical analyses using the TERMO thermodynamic model which corresponds to a closed system attaining thermal and chemical equilibrium with a minimum free energy and on the basis of the experiment in the hyperbaric plasma reactor designed by the authors. Figures 3; tables 2; references: 13 Western.

Effect of Vibration Treatment During Metal Solidification on Structure of Flat Castings

937D0137C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 2, Feb 93 pp 56-58

[Article by V.L. Pilyushenko, A.A. Troyanskiy, Yu.V. Kostetskiy, O.Ye. Chernyshev, S.N. Vislobokov, Donetsk Polytechnic Institute; UDC 621.746.58]

[Abstract] The advantages of horizontally positioned (or flat) castings for attaining oriented bottom-to-top solidification and the crystal structure nonuniformity in the solidification direction and the difficulty of producing an ingot with a uniform crystal structure by simply intensifying the heat removal from the bottom surface and additionally enhancing the heat and mass transfer processes in the two-phase zone and the liquid metal prompted a study of the possibility of refining the cast structure and increasing the homogeneity of flat castings solidifying under the conditions of oriented heat removal by vibration treatment during solidification. To this end, 30 kg 100x180x250 mm castings simulating a cast stamping blank or horizontal ingot are subjected to vibration treatment. Metallographic studies are carried out using transverse macrotemplates. A metallographic analysis shows that in ingots treated by horizontally and vertically applied vibrations at a 13-108 Hz frequency, the averaged maximum dendrite length decreases by approximately twofold. The dependence of the cast metal density on the vibration treatment frequency in the horizontal and vertical planes and the behavior of the adjusted liquid metal pool depth during the solidification process are plotted. The findings show that vibration treatment helps to refine the dendritic structure of flat castings solidifying under oriented heat removal within the entire frequency range whereby vibrations in the horizontal plane are more efficient. The optimum metal density and macrostructure homogeneity are attained at a 78 Hz frequency. Figures 3; tables 1; references 2.

Cast Single-Crystal Turbine Blades

937D0116A Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, Jun 93 pp 3-6

[Article by A.G. Bratukhin, R.Ye. Shalin, Ye.N. Kablov, V.N. Toloraiya, and N.G. Orekhov, All-Russian Institute of Aircraft Materials; UDC 621.74.04]

[Abstract] The technology of casting single-crystal blades for gas turbines is outlined, the basic process parameters being the axial temperature gradient Gz at the crystal growth front and the rate R of directional crystallization from a seed crystal. Four special heat-resistant carbon-free high-alloy steels have been developed suitable for this technology: 1. HR-32WNiCo, 2. HR-30MoNiCo, 3. HR-36MoNiCo, 4. HR-40NiCo. Two types of apparatus of directional crystallization of these alloys have been designed implementation of this technology: 1. PMP-2 for [curley bracket] 111-oriented crystal growth and directional heat removal from mold by radiation as mold is being withdrawn from heater (Gz $\simeq$ 2°C/mm, R= 3.0-3.5 mm/min); 2. UVNK-8P for [curley bracket] 001-oriented crystal growth and heat removal by cooling as mold is being withdrawn from heater (Gz $\simeq$ 8-9°C, R= 10-20 mm/min). With a smaller temperature gradient there is a greater proneness to streakwise segregation, almost none of it occurring in the UVNK-8P apparatus. Inversion of the density profile across the liquid-solid zone has, however, also to do with the alloy composition. Alloys containing heavier metals such as W and Re are prone to streakwise segregation, while lighter elements such as Ta tend to inhibit it. Dispersion hardening by heat treatment, which includes homogenization and two stages of aging, produces an alloy structure consisting of two coherently interlinked phases: solid solution of γ-phase nickel and precipitate of cubic γ'-phase Ni_3 Al particles. These particles - all of the same size, form, and composition - are distributed over the entire volume along the axes as well as in the interaxial spaces. The wear resistance of these single-crystal alloys is higher than that of conventional grain-oriented alloys, mainly owing to the absence of carbides responsible for microcrack formation under cyclic mechanical and heat loads. Their mechanical properties including wear resistance are characterized by an anisotropy, their fatigue strength retaining its anisotropy at temperatures up to 1000-1100°C. The alloys with [curley bracket] 111 orientation have a 15-20 % higher fatigue strength and 25 % higher ultimate strength under static loads at 20°C than those with [curley bracket] 001 orientation. Figures 5; tables 1.

Electroslag Remelting of Compacted High-Speed Steel Powders in Magnetic Field

937D0138B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 3, Mar 93 pp 41-45

[Article by M. Murgas, A. Pokusa, A.S. Chaus, Slovak Engineering University and Belarussian Polytechnic Institute; UDC 621.791.793.669.188.4]

[Abstract] The need to attain the necessary ductility which ensures the high resistance and reliability of cast tools in accordance with the operating conditions and client requirements and the possibility of improving the alloy structure and properties by switching from large ingots to microscopic, as has been done in powder metallurgy, prompted attempts to improve the methods of electroslag remelting of high-speed steel powders. It is speculated that the remelting of the consumable electrode made from compacted materials is accompanied by the refinement of the primary ingot structure, thus making it possible to develop a method of controlling the primary high-speed steel solidification on the basis of the electroslag process and utilize powdered waste. This is accomplished by applying a magnetic field to the electroslag remelting of an electrode made by compacting powder materials to a 65-80% density. Powder waste whose composition corresponds to high-speed steel R6M5 was used in the experiment; the powders were placed in an alundum ceramic thin-walled tube and vibration-compacted to the requisite density. A process block-diagram is cited; the method's effectiveness is assessed using templates for metallographic analyses. The behavior of nonmetallic inclusions in steel after electroslag remelting (EShP) and electroslag remelting under a magnetic field (EShP+MP) and the effect of the magnetic field on the steel's hot ductility are plotted. The

findings reveal that the use of the magnetic field makes it possible to lower the structural inhomogeneity of high-speed steels by altering the primary melt solidification mechanism due to the effect of Lorentz forces in the solidification zone. These favorable structural changes improve the tool operating properties. It is also noted that the magnetic field may be used to increase the hot ductility of high-speed steel in order to improve its plastic workability. Figures 5; tables 1; references 9: 6 Russian, 3 Western.

Cast High-Strength Corrosion-Resistant Steels of Austenitic-Ferritic Class

937D0116B Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, Jun 93 pp 8-13

[Article by B.I. Voronenko, "Prometey" Scientific Research Institute of Machine Construction Materials, Nizhniy Novgorod; UDC 621.74:669.14]

[Abstract] Replacement of austenitic stainless steels with cast austenitic-ferritic ones is considered, the latter being not less corrosion- resistant and producible with maximum nickel economy. Thirty grades of these steels produced and in service worldwide, six in the C.I.S. (Russia-Belarus-Ukraine) and seven in the U.S. (Escoloy 4590, Atlas 958, Ferralium 225, Ferralium 288, CD-4MCu, Paralloy 3FL, PH), are selected for a comparative evaluation of properties, especially mechanical strength and corrosion resistance. Important are, moreover, controllability of their structure by regulation of the ferrite content and of their phase composition by appropriate heat treatment. Production of these steels, which involves the usual melting-casting-solidification process, is surveyed with emphasis on various special techniques and patented key relevant inventions. Another important factor considered in this survey, in addition to corrosion resistance, is weldability. An example of these steels is is the C-06Cr20Ni8Mo3Al2 ($\leq$ 0.6 % C, 19-21 % Cr, 7.5-8.5 % Ni, 2.5-3 % Mo, 1.5-2 % Cu, 0.3-0.7 % Mn, 0.1-0.2 % Ti, 0.1 % Ce, 0.8-1.1 % Si, $\leq$ 0.03 % S, $\leq$ 0.03 % P,Azerbaijan Scientific Research Institute of Petrochemical Machinery Design. Its heat treatment consists of normalization at 1130°C for 2 h, air cooling, and for higher strength aging at 450-470°C for 8 h. Tables 1; references 21.

Cast Aluminum and Magnesium Alloys for Aircraft Construction

937D0116D Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, Jun 93 pp 18-20

[Article by V.V. Cherkasov and I.A. Zavarzin; UDC 621.74:669.715]

[Abstract] Cast aluminum and magnesium alloys for aircraft construction are described, with emphasis on steady improvement of properties as new alloys are being developed. They include high-strength Mg-Zn-Zr alloys, heat-resistant M-Nd-Zn-Zr and Mg-Y-REM-Zr (REM-rare-earth metal) alloys, high-strength Al-Zn-Mg-Zr alloys, high-strength corrosion-resistant Al-Cu-Mn alloys, and weldable corrosion-resistant Al-Mg alloy. Better performing and more economical alloys are still being added to these classes, while also the casting processes are being improved and especially so high-pressure precision casting. Tables 5.

Structure and Properties of Thin Ti-C-B Films

937D0138C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 3, Mar 93 pp 64-67

[Article by Ye.A. Levashov, I.B. Borovinskaya, V.I. Kosyanin, Yu.V. Bogatov, L.M. Kryukova, Moscow Steel and Alloys Institute; UDC 620.18]

[Abstract] The shortcomings of existing low- and medium-resistivity resistors (10-1,000 Ω/cm^2) made from thin chromium, Ni-Cr alloy, tantalum nitride, and silicide of refractory metals with nickel, particularly the low thermal stability and an increase in the thermal coefficient of linear expansion (TKS) as well as production difficulties, prompted an attempt to use the method of self-propagating high-temperature synthesis (SVS) for making titanium carbide and titanium diboride targets. To this end, the structure and properties of thin film resistors (TPR) produced by magnetron sputtering of SHS targets are investigated. The TiC-TiB_2 targets are produced by HSH compacting under the conditions necessary for minimizing porosity. The phase composition, structure, physical and mechanical properties of the HSH products, and the thermal coefficient of linear expansion within a 100-1,000°C range are examined by standard methods. The targets are sputtered onto a stationary substrate in an URM 3.279.014 magnetron unit in direct or alternating current using a three-electrode circuit. The behavior of the thin film resistor parameters during annealing in the air, the element distribution in the film, and the dependence of the thermal coefficient of film resistance on the vacuum annealing temperature are plotted. Specifications (TU 88-29-185—91) for SST 6040 targets are developed on the basis of the findings. Optimum thin film resistor heat treatment conditions which make it possible to attain record properties are determined. Figures 3; tables 1; references 6.

Laser Ignition of Sintering Mixture

937D0138D Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 3, Mar 93 pp 83-84

[Article by T.V. Detkova, Ye.F. Vegman, A.R. Zhak, Moscow Steel and Alloys Institute; UDC 622.785]

[Abstract] The method of laser ignition of the sinter burden first proposed by the Moscow Steel and Alloys Institute (NISiS) in 1991 and tested in a lab laser in 1992

using a scanning laser beam and thus eliminating the ignition hearth is described. The environmental advantages of the method—the laser consumes only electric power—and the virtually perfect thermal laser efficiency are discussed. The experiment is carried out using a TL-1.5 laser with a maximum output power of 1,500 W at a 19 mm beam diameter. The sinter burden from the Cherepovets Integrated Iron and Steel Works was ignited. The specific burden compositions, radiant intensities, and other ignition parameters are outlined. Laser ignition is accompanied by high-speed surface layer drying and heating, dehydration, decarburization, and mixture fusing in the heat affected area. The crust microstructure contains magnetite crystals forming from the melt; calcium ferrites are present in some cases. The sinter machine yield increases by 10-15% while harmful CO, CO_2, SO_2, and NO_x discharges into the atmosphere are completely eliminated. Figures 1.

Intensive Methods for Producing Aluminum Castings for Modern Machinery

937D0135A Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 3-4

[Article by A. G. Bratukhin, N. S. Postnikov, and Ye. B. Glotov; UDC 621.74:669.715]

[Abstract] On the basis of a system for controlling the structural-phase state of castings and industrial requirements, cast aluminum alloys and technological processes were developed that guaranteed the required level of operational characteristics to prototypes of modern machinery. The alloys included VAL8 (a high-strength Silumin intended for production under pressure in a metal mold or by liquid stamping), VAL12 (the highest-strength cast aluminum alloy, successfully rivaling deformed aluminum alloys, low-carbon steels, bronzes, and brasses; produced in a metal mold or by stamping), and VAL16 (a weldable, corrosion resistant alloy produced in a metal mold or cast into sand molds). The technological processes included surface deformation (pneumatic abrasive processing (PA) with sand, marshalite, or synthetic corundum and vibrational polishing (VP) or vibrational compaction (VC) with steel beads), hot isostatic compaction (HIC), and thermovacuum processing (TVP). The complex approach toward improving the production of castings guaranteed an effect on all primary elements of the structure and was a necessary condition for assuring the operational reliability of cast products and the efficient and economic utilization of nonferrous metals.

Formation of Structurally Sensitive Properties in Aluminum Castings During Isostatic Compaction

937D0135B Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 5-8

[Article by N. S. Postnikov; UDC 621.74:669.715]

[Abstract] An important method for processing aluminum castings is high-temperature isostatic compaction (HIC), which allows one to change the structure and properties of castings and to influence production indicators by reducing metal consumption, simplifying the pouring gate-feed system, lowering requirements for the casting properties of alloys, etc. HIC, the process of simultaneous action of high gas pressure and temperature on a casting, is an effective method for improving the casting's quality in that it eliminates pores, flaws, and micropores that do not extend to the surface, and it improves other structural elements. Although the process is highly effective, its results are far from being well-defined. In this work, the author analyzed HIC by evaluating the special properties of AK8, AK8M3ch, AK7ch, AM5, AM4,5Kd, VAL12, and VAL16 castings (corrosion under stress, impermeability, high-temperature strength, etc.) as well as the traditional properties (structure, strength, plasticity) because traditional tests alone do not often give comprehensive results on the operational reliablility of cast items. The author concluded that HIC may be a prospective method for increasing the density of items cast under pressure because it practically completely eliminates porosity and improves the feasibility of strengthening by thermal processing. However, the application of HIC should not preclude the use of other means of increasing the density of castings such as improving pouring gate systems and regulating the intake and pressing rates in order to assure laminar filling of the mold with a continuous melt flow. New concepts of controlling the quality of aluminum castings should involve optimizing decisions about the selection of an efficient technology, including HIC, whose widespread application is currently an objective reality. Figures 2; references: 10 Russian.

Production of Metallic Composite Materials by Impregnation Methods

937D0135C Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 8-13

[Article by R. Ye. Shalin and A. A. Zabolotskiy; UDC 621.74.002.6:669.2/.8]

[Abstract] Based on a literature review, the authors determined that the current level of develoment of metallic composite materials (MCM) is characterized by the following: 1) the priority development of casting methods, 2) the development of new modifications of liquid phase technological methods and the corresponding equipment, 3) the initial theoretical development of these processes, 4) the start of a deeper investigation of phenomena at the boundary "matrix melt-filler," particularly taking into account the external pressure, 5) the proliferation of works on creating and studying the properties of composite materials (CM) produced by liquid phase methods, particularly CM with an aluminum matrix reinforced by particles or short fibers, and 6) non-traditional uses of CM. The authors noted that in Russia, particularly at VIAM [All-Union

Scientific Research Institute of Aviation Materials], various impregnation methods and the corresponding equipment have been developed and utilized. Figures 6; references 6: 3 Russian, 3 Western.

Modification of High-Temperature Nickel Alloys With Disperse Particles of High-Melting Compounds

937D0135D Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 13-14

[Article by O. Kh. Fatkullin and A. A. Ofitserov; UDC 621.746.56:669.14.018.44]

[Abstract] In this work, the authors introduced finely dispersed high-melting modifier particles (carbides, nitrides, and carbonitrides) into ZhS3DK, ZhS6U, VZhL12U, and ZhS32 nickel alloys in the form of pellets prepared by powder metallurgy methods. In order to isolate modifier particles from each other, the modifier powder was mixed with powders of the metals Nb, Ti, or Cr. Favorable results were obtained upon modifying ZhS32 with niobium nitride and ZhS6U and ZhS3DK with titanium carbonitride; their endurance limits (σ, MPa) increased. When ZhS3DK was modified with niobium nitride, its σ_b, δ, and a_H values exceeded the technical specifications (TS) for strength and plasticity, and its lifetime corresponded to the TS. Similar results were achieved in works by specialists at NIAT [Scientific Research Institute for Aviation Technology], NPO "Saturn," IPM [Institute of Problems in Material Science], Ukrainian Academy of Sciences, MISiS [Moscow Order of the Red Banner Of Labor Institute of Steel and Alloys], the Omsk Polytechnic Institute, and others. The authors concluded by affirming the feasibility of introducing the modification of high-temperature nickel alloys with small amounts of high-melting compounds into industry in the near future. Figures 1.

High-Temperature Pressure-Static Processing of Castings and Improvement of Their Lifetime Charcteristics

937D0135E Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 17-18

[Article by T. I. Fomicheva, N. P. Klochkova, and G. L. Khodorovskiy; UDC 621.747]

[Abstract] Regardless of the high effectiveness of the pressure-static or hot isostatic pressing (HIP) process, it is far from being simple or yielding well-defined results. It has become clear that it is necessary to investigate the pressure-static process in conjunction with casting technology. Only such an approach will guarantee maximum effectiveness. The process is sensitive to exact adherence to technological parameters. Besides, not all alloys respond to HIP in the same manner, e.g., recently, it became clear that VT20L aluminum alloy's ultimate strength steadily declines as a result of the pressure-static process. Pressure-static processing of castings under various conditions leads to welding of 80-90% of the defects identified by X-ray diffractometry. The remaining defects comprise two groups: 1) defects connected to the surface via channels or a porous connector and 2) subsurface defects or defects located in thin walls. Pressure-static processing of titanium castings has been economical due to a reduction in the pouring gate-feed system and a shortening of the block for almost the entire range of products; however, the positive effect for aluminum castings has been only 8-10% of the range of products. In this case, a prospective variant is high-temperature processing of aluminum castings under pressure, where they are produced in a dust medium (graphite dust and talc) with the usual hydropress. Widespread introduction of pressure-static processing of castings is an objective necessity; however, it is feasible only when the method results in a significant cost reduction. Figures 4.

Status and Prospective Development of Titanium Alloy Shaped Castings

937D0135F Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 21-22

[Article by A. G. Bratukhin, G. L. Khokorovskiy, and K. K. Yasinskiy; UDC 621.74:669.295]

[Abstract] Titanium alloy shaped castings are more economical than deformed items, and several of the castings' important characteristics do not differ from those of deformed items because of the titanium alloys' high mechanical properties. This makes titanium castings ideal for use in aircraft production. In this work, a number of new titanium alloys were evaluated for this application. They included VT35L, a high alloy known for its high strength and hardenability; VT20L, a lower alloy with properties corresponding to those of VT35L; VT5L and VT6L, structural alloys recommended for producing castings that operate at $\leq$ 350-400° C; VT9L, a high-temperature structural alloy (operational T $\leq$ 500° C); and VT21, recommended for producing castings of average complexity (flowability—480-500mm). A technology for casting in synthetic corundum molds, whose operating surfaces had coatings that were chemically resistant to titanium, was developed. High precision and the required chemical inertness were combined in these molds. As a result of combined work by the Balashikhinskiy Foundry and Machine Plant, PO "Promavtomatika" and NIAT [Scientific Research Institute of Aviation Technology], automated process control systems (ASU TP) based on "Grasmikro" microprocessors were designed and introduced. The 833-D and DVL-250 units were equipped with these ASU TPs. The authors noted the importance of developing new labor saving, low-cost technologies not associated with the use of additional scarce materials for the production of items from titanium alloy scrap. The medical prosthesis, sporting equipment, and pump industrial sectors, to name a few, have already experienced favorable results.

However, work on converting technology to the utilization of titanium alloy scrap must be conducted more intensively in order to guarantee a significant economic effect. Figures 1.

Production of Shaped Steel and High-Temperature Alloy Castings by the Directional Solidification Method

937D0135G Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 25-26

[Article by V. A. Nikishin; UDC 621.74.045:669.14]

[Abstract] The All-Union Scientific Research Institute for Aviation Materials (VIAM) developed, accepted, and introduced into production a process for casting shaped items from high-strength steels and high-temperature alloys by the directional solidification method (DSM). Its distinguishing feature is heating the mold to the metal's melting point and higher and directionally cooling the mold, filled with metal, by means of controlling its transfer from the furnace to the cooling zone, which guarantees directional solidification of the metal at all walls of the cast, regardless of their spatial arrangement. Series production of DSM cast items from VNL-3 steel for the MIG-29 fighter was accepted at the aviation plant "Sokol." With the introduction of DSM, possibilities have been widened for the development and use, in the manufacture of items with complex shapes, of new alloys such as intermetallide alloys based on the Ni_3Al phase that are not technologically efficient for the usual precision casting methods. Figures 3.

Wear-Resistant Cast 90Cr2Mn9VTiN$_2$ Steel for Mining and Metallurgical Equipment

[937D0116C Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, Jun 93]

[Article by V.M. Kolokoltsev and L.V. Dolgopolova, Magnitogorsk Institute of Mining and Metallurgy, V.V. Konyukhov, S.V. Kadnikov, and V.D. Naumenko, Magnitogorsk Metallurgical Combine; UDC 621.74.002.6: 669.018.25]

[Abstract] A steel containing metastable austenite has been developed at the Magnitogotsk Institute of Mining and Metallurgy, replace stable austenitic steels for casting crusher and grinder parts subject to high static and impact loads during mining operations. This is the 90Cr2Mn9TiV N, steel (0.75-0.95 % C, 8.5-10.0 % Mn, 1.5-3.0 % Cr, 0.02-0.1 % Ti, 0.01-0.05 % V, 0.01-0.04 % N_2, 0.2-0.06 % Si, 0.006-0.05 % Ca), is essentially a Cr-Mn alloy steel with a Ti-V-Ca admixture. Its mechanical characteristics measured in an abrasive medium are: 0.2 % yield strength 395-480 MPa, ultimate strength 680-760 MPa, percentage elongation 17-21 %, percentage area reduction are 21-26 %, hardness 200-230 Bhn, and Charpy V-notch impact energy absorption KCV= 0.9-1.3 J/mm^2. Its shrinkage in casting is 2.5-2.6 % and its fluidity is also not much worse that that of the C-110Mn13 cast steel it is to replace so that thin parts can be readily produced. Quenching in water from 1050-1200°C temperatures somewhat decreases its hardness and substantially increases its strength. The energy indicator of impact strength decreases as the temperature falls, from 1.2 J/mm^2 at +20°C to 0.4 J/mm^2 at -60°C, fracture by the viscoelastic mechanism being still predominantly ductile at temperatures down to 0°C. Metallographic and microfractographic examination has revealed precipitation of FeO x MnO inclusions (films, clusters) along grain boundaries, presence of CaO x FeO . SiO_2 inclusions (crystals, powder), and insoluble particles of carbides on grain boundaries. Figures 1; references 3.

Specialized Equipment for Investment Casting of High-Temperature Alloys and Steels

937D0135H Moscow LITEYNOYE PROIZVODSTVO in Russian, Apr 93 pp 29-33

[Article by M. P. Kuleshov, V. P. Kalinin, Ye. B. Glotov, and Ye. N Kablov; UDC 621.74.045]

[Abstract] In this work, the authors described new technological processes for steel and high-temperature alloy investment casting, which is the primary method for producing precision thin-walled cast items. Vacuum induction smelting with temperature-ramped processing of high-temperature alloys, first developed and introduced by MMPO "Salyut," NPO "Saturn," IPL [Casting Problems Institute, Kiev], and UPI [Urals Pedagogical Institute, Yekaterinburg] and utilized in producing heavy-duty bracket components for the "Buran," has improved the quality of castings and the metal utilization factor and has sharply reduced waste. A new generation of vacuum induction smelting-casting apparatuses with microprocessor control, designated UPPF, and a modernized version of the existing VIAM-24 have been produced for casting thin-walled blanks for heavy-duty parts with an equiaxial structure. A Rzhev plant has manufactured apparatuses for continuous and semicontinuous directional solidification of castings. The UVPP-2, an apparatus for semicontinuous directional solidification of thin-walled and complex castings, has been developed as a follow-on to the UVPP-1 that was introduced at the Gorkovskiy Aviation Plant. The Scientific Research Institute for Aviation Technology (NIAT) and RMPO, Rybinsk, have developed robotic production lines (RPL) based on the RPS-401M robot for manufacturing casting molds for gas turbine engine blades. Figures 3.

Specialized Equipment for Titanium Casting Production

937D0135I Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 33-34

[Article by A. Ye. Deshin, A. Ya. Balberov, M. P. Kuleshov, and G. L. Khodorovskiy; UDC 621.745.35]

[Abstract] In this article, the authors evaluated six domestically produced apparatuses for the smelting-casting manufacture of titanium alloy castings. The 833D, U17-3, DVL-75, DVL-250, DVL-250M, and DVL-160 are vacuum electric arc slag-lined apparatuses with consumable electrodes and a centrifuge with a vertical axis of rotation. The 833D and DVL-250 are equipped with microprocessor-based automated control systems. According to the authors, all the new generation smelting-casting apparatuses are state-of-the-art, based on their technical parameters, efficiency, reliability, safety, and level of automation. Additionally, the DVL-20K, a vacuum-compression apparatus whose maximum inert gas pressure (10 MPa) will enable castings to be made without a centrifuge, is in the design stage. At NIAT [Scientific Research Institute for Aviation Technology], the LTS-1 is being designed for casting titanium dentures that will then be coated to resemble natural or gold teeth. Along with the engineering development, acceptance, and supply of titanium castings, NIAT and RPO "Electromekhanika," in collaboration with other plants and manufacturers, are prepared to fulfill requirements for the design development, manufacture, and operational start-up of smelting-casting apparatuses for titanium casting. Figures 3.

Specialized Shops for Vacuum Casting of Gas Turbine Engine Blades

937D0135J Moscow LITEYNOYE PROIZVODSTVO in Russian No 4, Apr 93 pp 35-36

[Article by L. M. Shumilov, V. P. Kalinin, and V. M. Trofimov; UDC 621.74:658.2]

[Abstract] The current technical level of gas turbine engine (GTE) blade casting production has been achieved, in part, due to the creation of a new, modern generation of casting shops based on unified architectural-engineering decisions that have provided for efficiency in the arrangement of industrial divisions and sections, the mix of equipment and laboratories within them, and the organization of warehouses and transportation connections in order to assure freight flow. According to the authors, the shop should be located on two floors—1) all preparatory divisions for the preparation and storage of stock and bulk materials, regeneration of synthetic corundum, quality control of raw materials, preparation of ceramic cores, and all power and sanitary engineering services; 2) primary engineering divisions and sections for preparing molds and mold blocks and preparing ceramic shells (molds), the roasting-smelting-casting division, the section for finishing and heat-processing castings, and the complex quality control laboratory for GTE blades. The authors argue that having primary production on the second floor improves vacuum hygiene. Future improvements on shop design include automating several processes, such as deposition of ceramic coatings onto mold blocks, transport of ceramic shells from the roasting furnace to the holding furnace and thermostating down the cast in the UPPF-3M apparatus, cleaning of castings and recovered cast material, etc.

Change in the Magnetic Transformation Temperature of Ultradisperse Particles of Fe Group Metals Produced by the Electrolytic Method on Active Carbon

937D0140C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 5, May 93 (manuscript received 14 Apr 92) pp 48-51

[Article by M.V. Astakhov and Ye.P. Borisova, Moscow Steels and Alloys Institute; UDC 541.1:549.67]

[Abstract] A low-temperature electrolytic method of producing ultradisperse particles of Fe group metals on conductive porous carriers (such as active charcoal) was developed. The new method had made it possible to produce metal particles less than 10-15 nm in diameter containing up to 60 percent (by weight) metallic phase that has been confirmed by microanalysis to be evenly distributed throughout the entire volume of the particle. Scanning electron microscopy has revealed the presence of large (up to 10 μm) particles of an applied phase whose shape and dimensions repeat the carrier's pore structure. X-ray diffraction studies performed on the same sample particles have demonstrated the absence of crystal-phase particles smaller than 15 nm in size. Transmission electron microscopy has, moreover, proved the presence of an ultradisperse (<10-15 nm) phase, thus establishing that the large particles are actually not monolithic but are instead conglomerates of ultradisperse particles up to 15 nm in size whose high dispersivity causes the samples to be x-ray amorphous. In the studies reported herein, an in situ Mossbauer spectroscopy technique was used to establish the phase composition of ultradisperse particles of superparamagnetic Fe_2O_3 formed as a result of electrodeposition of iron irons onto type BAU active charcoal at temperatures up to 553-583 K. In order to study the interaction of metals in the electrodeposition process, researchers developed a method of combined application of 1) iron and nickel and 2) iron and cobalt. When the new method was used, ferromagnetic phase components with effective magnetic fields of 349.2 and 341.8 kOe appeared in the spectra of Fe-Ni-BAU and Fe-Co-BAU, respectively. These phases were identified as Fe-Ni and Fe-Co solid solutions. The ultradisperse particles did not exceed 15 nm in size. Also present in the specimens' spectra were doublets of lines corresponding to superparamagnetic Fe_2O_3 that likely formed as a result of oxidation of the most disperse iron-containing particles. The change in the phase composition of the ultradisperse particle on active charcoal was recorded at 10 temperatures between 293 and 923 K. The reduction of the Fe_2O_3 ultradisperse particles was attributed to their interaction with the carbon matrix. The reduction of Fe_2O_3 was determined to begin at 553 K and to be fully complete at 583 K. The

effect of the size factor on the ferromagnetic → paramagnetic phase transition temperature was established. The Curie points of the ultradisperse particles synthesized were found to be much lower than that of bulk ferromagnetics (i.e., 623-673 for Fe-Ni and 653-693 K for Fe-Co). Figures 3, table 1; references 6 (Russian).

Mechanical and Damping Properties of Graphitized Steels after Isothermal Heat Treatment

937D0123A Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 93 pp 9-10

[Article by A.I. Skvortsov, Kirov Polytechnic Institute, and L.I. Agapova, Central Scientific Research Institute of Materials Science; UDC 620.17:669.15-196]

[Abstract] A study of graphitized steels 120Si2Ni2Al and 130Co6Si2 steels, for comparison also gray cast iron filled with globular graphite, was made concerning their mechanical and damping properties after isothermal heat treatment. The steels had been produced by melting pure raw materials in an open induction furnace and then forged into round bars 15-20 mm in diameter. The cast iron was produced by remelting semifinished blanks from the Chusovoy Metallurgical Combine in an induction furnace. Isothermal heat treatment consisted of soaking in saltpeter melt at a temperature within the 330-380°C range after heating to a temperature within the 880-900°C range and subsequent cooling in that melt. Tension tests were performed in an IM—20 machine, the diameter of the bars having been reduced to 6 mm over a 50 mm gage length. Impact tests were performed in an MK-30 striker machine and damping tests were performed with a torsion pendulum. For comparison, the steels and the cast iron were identically tested after other heat treatments: 1) annealing at 830°C, 2) quenching from 850°C and tempering at 190°C, 3) quenching from 850°C and then tempering at 490°C. The results indicate that the given isothermal heat treatment has increased both the strength and the plasticity of all three materials more but their damping capacity much less than have the other heat treatments. It has improved the properties of the steels more than those of the cast iron. Figures 1; tables 3; references 6.

Resistance of Cr-Mn-Ni Steel Welds to High-Temperature Embrittlement

937D0123C Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 93 pp 21-23

[Article by T.S. Kuznetsova, Volgograd Polytechnic Institute, T.A. Chernyshova, Institute of Metallurgy imeni A.A. Baykov, and S.U. Myakisheva, All-Russian Scientific Research and Design Engineering Institute of Petrochemical Apparatus; UDC 669.15'26'74'24:621.79]

[Abstract] A study of austenitic-martensitic steel 05Cr18Ni5Mn2Ti containing 6 % δ-ferrite along with two ferritic-austenitic steels, 05Cr18Ni5Mn10Mo3V containing 40 % δ-ferrite and 05Cr18Ni5Mn10Mo3VN$_2$ containing 9 % δ-ferrite, was made concerning embrittlement of their welds at elevated temperatures. They were produced in an open induction furnace and rolled into to 5 mm thick plates, which were then quenched in water from 1100°C. Plates of each steel were welded automatically with a tungsten electrode without filler in an argon atmosphere. The welds were then aged at 300°C, at 400°C, and at 500°C for 1 h, 10 h, 100 h, and 1000 h at each temperature. Examination under transmission optical and electron microscopes revealed resulting changes in the structure of the parent metal, of the cast seam metal, and in the heat-affected zone. Fractography of impact specimens was performed with the aid of extractive carbon replicas. The phase composition was determined determined with the aid of x-ray diffractometry and structural analysis. Embrittlement of welds was detected within the 350-500°C temperature range, evidently caused by processes taking place in the δ-ferrite: 475° embrittlement of δ-ferrite or precipitation of excess phases inside δ-ferrite grains and at interphase boundaries. The plasticity of these welds was found to depend not on the amount of δ-ferrite but rather by amount of those excess phases. The aging process was found to begin at lower temperatures in the seam than in the parent metal. The maximum allowable long-service temperature is 300°C for both 05Cr18Ni5Mn2Ti and 05Cr18Mn10Ni5Mo3V steels, lower than 300°C for 05Cr18Mn10Ni5Mo3VN$_2$ steel. Figures 1; tables 2; references 4.

Cr-Mn-Mo-V Steels for Hot-Forming Tool

937D0123D Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 93 pp 25-28

[Article by M.M. Sandomirskiy, T.I. Titova, and I.P. Galenko, Industrial Association "Izhorsk Plant"; UDC 669.14.018.254]

[Abstract] A study of 50CrMnSiMoV and 50Cr2MnSiMoV steels produced at the Izhorsk Plant for hot-forming hammers was made, the steels having been produced in a basic electric-arc furnace and in a basic induction furnace. Ingots of both steels were forged into 240 mm long bars 70x160 mm^2 in cross-section, 240 mm long bars 80x160 mm^2 in cross-section, and 160 mm long bars 40x70 mm^2 in cross-section. Some of the ingots had been hot-rolled prior to being forged. The bars were heat treated by quenching in oil from 910-930°C and subsequent high- temperature tempering at 520-540°C for 3-5 h. They were then tested for fatigue (ultimate strength and 0.2 % yield strength) under a compound cyclic thermomechanical load: mechanical load varied from +145 N/mm^2 tension -145 N/mm^2 compression and alternating 300-500- 300°C or 300-550-300°C heat load, also for hardness. The fatigue strength was evaluated on the basis of both 2000 and 10,000 temperature cycles. Microdistortions in the crystal lattice (relative change of the a-parameter) were evaluated by x-ray radiography of the solid α-solution, namely from the widening of its (110) and (220) interference lines. Determinations of carbides was made by electrolytical separation of phases and subsequent phase analysis of the anodic deposit in an x-ray diffractometer. For comparison, six conventional appropriately heat treated steels

for hot-forming hammers (50CrNiMn, 50CrNiW, 50CrMnW, 50CrMnSi, 50CrMnSi, 50CrMnWV, 50CrMnSiWV) were analogously examined and tested. The results confirm the suitability of both 50CrMnSiMoV and 50Cr2MnSiMoV steels for these tool. Figures 6; table 1; references 6.

Effect of Phosphorus and Boron on Recrystallization of Low-Carbon High-Strength Automotive Sheet Steel

937D0123B Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 93 pp 10-14

[Article by A.M. Nesterenko, L.M. Storozheva, and O.A. Girina; Institute of Ferrous Metallurgy, Dnepropetrovsk; UDC 669.14.018.265: 620.184.5]

[Abstract] A study of cold-rolled 08YuP and 08YuPR aluminum-killed steels (0.030-0.060 % C, 0.046-0.063 % Al) was made concerning the effect of combined 0.026-0.088 % phosphorus and 0.009-0.022 % boron microaddition on their recrystallization, microstructure, and grain orientation. Industrial grades of these steels were hot rolled (final temperature 860- 880°C, coiling temperature below 550°C) and then annealed in a stack furnace prior to being cold rolled to 20-75 % reductions. Laboratory grades of these steels were produced in a laboratory vacuum furnace and cast. Ingots of these steels weighing 50 kg were hot rolled (final temperature 880-900°C) and then precooled by an air-water jet to 530°C for annealing at this temperature prior to being cold rolled to 75 % reduction. For recrystallization, specimens of both steels were placed inside vacuum flasks and either heated at a 25°/h rate to 500°C, to 550°C, and to 575°C without holding at each temperature or heated to 575°C and held at this temperature for 0.5 h, for 1 h, for 3 h, and for 6 h. Lengthening the holding time at 575°C lowered the temperature at which primary recrystallization began. Recrystallization to a larger ferrite grain size improved the punchability of steel sheet, in accordance with both Haltgren and Wright criteria. The ferrite grain size increased with increasing phosphorus and boron content in hot-rolled steel, boron facilitating comminution of cementite grains and phosphorus accelerating the recrystallization of cold-rolled steel. While the low-carbon steels with a phosphorous microcontent had distinct grain orientations beneficial for punching, the boron microcontent greatly decreased the pole figure density of these orientation. Boron was, moreover, found to initiate primary recrystallization and to ensure a more even completion of this process. An analysis using data on high-grade 08Yu steel produced by the Novolipetsk Metallurgical Combine and its U.S. analog M 1008 steel indicates that 08YuP (killed) steel is better than plain 08Yu steel, while 08YuPR steel (killed and recrystallized) is worse than plain 08Yu steel in terms of strength characteristics and punchability. Figures 5; references 11.

Stress Simulation During Wire Drawing With Current Stimulation

937D0137A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 2, Feb 93 pp 33-36

[Article by V.I. Bazaykin, V.Ye. Gromov, L.M. Poltoratskiy, V.N. Perepyatko, Siberian Metallurgical Institute; UDC 621.778:539.37]

[Abstract] Deformation in the drawing die with a conical hole under various assumptions is discussed, and an attempt is made to plot the stress field on the basis of known deformation formulae according to the equations of motion which are plastically connected to kinematics and sense the effect of current which stimulates the straining micromechanisms. The deformation configuration and the axial and radial stress distribution along the wire radius are plotted. The conclusion is drawn that if the drawing process kinematics are described by correct mathematical equations, it is sufficient to complement the equations of motion with only one assumption that certain components of the stress and deformation rate deviator-tensors and add a shear strength constant to the proportionality factor. This makes it possible to plot the physically feasible stress field. The findings show that the drawing process may be relaxed with respect to the stresses and forces due to external stimulation by electric current. It is shown that since the deformation rate in the straining zone is virtually constant, a decrease in the shear stress intensity is equivalent to a decrease in the material yield point. Figures 2; references 6: 5 Russian, 1 Western.

Composite Welding Wire Microalloying With High-Activity Elements

937D0136C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 1, Jan 93 pp 84-85

[Article by A.P. Stovpchenko, I.N. Zigalo, Dnepropetrovsk Metallurgical Institute; UDC 621.791.75:669.018]

[Abstract] The shortcomings of existing methods of adding highly active microalloying elements (rare earth elements (RZE), Zr, Ti, Nb, etc.) to liquid steel in the ladle during the tapping or into the ingot which is necessary for improving the welding properties and weld metal quality and the inhomogeneity of element distribution in the ingot cross section and height prompted a study of welding wire alloying methods which are free from these flaws. Tests of a welding wire produced by microalloying whereby the high-activity elements do not interact with the liquid, solidifying, and rolled metal up until entering the welding bath demonstrated a much greater wire efficiency. The rare earth and other element concentration in the weld made by a wire with a 2 mm diameter from steel Sv-14G2S with elements added by various methods and the outcome of welding and performance tests are summarized. The new wire is more efficient and is characterized by a lower microalloying element consumption. The principal feature of composite wire production is ensuring hot rolling of ingots with a tubular element from the microalloying elements' ferroalloys and subsequent drawing. The method makes it possible to add high-activity elements in the free state (which are not bound to steel impurities) and produce high-quality inoculated welds. Tables 3; references 2.

Ultrasound Microwelding of Aluminum Conductors With Chemically Deposited Coatings of the System Nickel-Boron

937D0141A Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 5-7

[Article by A.P. Rydzevskiy, candidate of technical sciences, and I.P. Yakovlev, engineer, Precision Electronic Machinebuilding Design Office, and L.S. Tsybulskaya, candidate of technical sciences, and T.V. Gayevskaya, candidate of technical sciences, Chemical and Physical Problems Scientific Research Institute, Moscow; UDC 621.791.16:621.3.049.75]

[Abstract] The effectiveness of the ultrasound microwelding of aluminum conductors with chemically deposited nickel-boron films was studied. The films were precipitated from a solution consisting of the following (mol/l): nickel chloride, 0.04; sodium potassium tartrate, 0.16; ethylenediamine, 0.06; sodium hydroxide, 0.75; and sodium borohydride, 5×10^{-3}. The solution had a pH of 13.7 +/- 0.1. 5-Nitrobenzimidazole (1.6×10^{-4} mol/l), uracyl (1×10^{-5} mol/l), and 1-phenyl-5-mercaptotetrazole (1×10^{-5} mol/l) were used as stabilizers. The latter resulted in mat films, whereas the first two stabilizers mentioned resulted in glossy films. The concentration of boron in the film was varied from 0.1 to 2 dm^2/l by increasing the load density. Coatings 5-6 μm thick were obtained at a deposition temperature of 82 +/- 2°C with a deposition time of 45-60 minutes. Some of the films were heated in an inert argon atmosphere at 300, 500, and 800°C for 1 hour. Silicon-doped (≤1 percent) aluminum leads that measured 35 μm in diameter and that had been coated with nickel-boron films were subjected to ultrasound microwelding on an EM-4020B automatic welding machine. Two types of aluminum wire were used, the hard wire AK09PT and the soft wire AK09A. The glossy films formed better contact joints with the aluminum conductors than the mat coatings. The failure of the mat films to form strong joints with the aluminum after the ultrasound microwelding was attributed to the films' high degree of surface roughness. Glossy nickel-boron films containing 20-25 percent boron were found to be highly corrosion resistant, have minimal surface roughness and microhardness, have an amorphous structure, and result in the best joints with aluminum when subjected to ultrasound microwelding. The said films were deemed effective as replacements for gold coatings in the manufacture of printed circuit boards and microassemblies in the electronics and watch industries. Nickel-boron films heated to ≤500°C were found to result in strong welds with aluminum and were recommended for use in metal and glass ceramic microcircuit cases with aluminum wiring in a case-chip scheme to eliminate the formation of intermetallides at the welds. Figures 3, tables 2; references 13: 9 Russian, 4 Western.

Mathematical Model of Penetration During Laser Microwelding of Various Materials

937D0141B Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 8-9

[Article by A.V. Panyukhin, candidate of technical sciences, and B.N. Badyanov, doctor of technical sciences, MIEM-TU [not further identified]; UDC 621.791.947:563.2]

[Abstract] A mathematical model and computer program for modeling the penetration of thin-walled products and the temperature field developed in the heat-affected zone during pulse laser welding of plates made of various materials were developed. The mathematical model developed is in the form of a three-dimensional nonstationary two-phase heat conduction problem. The new method significantly reduces the amount of working memory and computation time required to develop a model and is suitable for use on personal computers operating in an MS DOS environment. The new model may be used to perform numerical experiments that can in turn quickly determine optimum welding conditions for producing welds with a specified required geometry (for example, when sealing the cases of electronic instruments and integrated circuits). The proposed computation method is suitable for use with all basic fusion welding techniques. Figures 2; references 13: 10 Russian, 3 Western.

Welding Zone Resistance During Spot Microwelding

937D0141C Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 9-11

[Article by E.V. Bumbiyeris and Ye.S. Lutsuk, Riga Technical University; UDC 621.791.76.037]

[Abstract] The basic principles of the classical theory of electrical contact and empirical data regarding welding thick components were used to analyze the unique features of welding zone resistance during spot microwelding. A model of welding zone resistance was proposed according to which resistance is the sum of the resistances of the area of contraction in the electrodes and in the components in the presence of a single metallic or quasi-metallic contact chain (the thickness of which depends on the applied compressive force and on the presence and thickness of a nonmetallic film on the components) between them. A computer program was developed to calculate welding zone resistance as a function of the size of the contact between components. The program was verified in a series of experiments. The welding zone resistance of specific components was calculated, and the resultant data were compared with results obtained by using existing formulas. The two sets of results sometimes differed significantly depending on the size of the contact. The proposed method was recommended for use in predicting the initial stage of heating based on measured welding zone resistance and in thermal calculations performed for spot welding processes. A comparison of the results calculated in accordance with the proposed model and actual measurements indicated that in cases where the contact area is small, the discrepancy between the calculated and measurement results does not exceed the measurement error. In cases where the size of the contact area is between 0.75 and 1.5 mm, however, the measured resistance is somewhat higher than that calculated by using the proposed formulas. Figure 1, table 1; references 5 (Russian).

Improving the Capillary Tools Used for Microwelding

937D0141D Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 11-12

[Article by A.I. Kolychev, candidate of technical sciences, V.V. Zenin, candidate of technical sciences, and Ye.K. Kovshikov, doctor of technical sciences, Voronezh Polytechnic Institute; UDC 621.791.18.002.54:681.518.54]

[Abstract] A series of experiments were conducted to improve the capillary tools used in microwelding. Tools with cylindrical and oval capillary openings were studied on UZS.A-209(UZS = ultrasound welding) and EM 4020 B automatic welding machines. AK0.9PM aluminum wire with a diameter of 35 μm (σ_t = 220-240 MPa; δ = 3-4 percent) was used in the experiments along with silicon wafers that had been sprayed with a 2-μm-thick layer of aluminum. The tool with an oval capillary opening resulted in stronger connectors. On the UZS.A-20 automatic welding machine, the height of the connector was guaranteed by the device forming the terminal. The connectors formed by the tool with an oval capillary opening on the EM 4020 B automatic welding machine were not as strong as those produced on the UZS.A-20 because of the great variance in the wire connectors' arc height. One possible remedy for this problem, i.e., designing the capillary opening to have a variable cross section by altering the oval's major axis, was tested. Experiments were performed on the EM 4949B and UZS.A-20 automatic welding machines with a maximum oval diameter of $1.3d$ in the opening's center cross section and $1.7d$ at the opening's outlet and an opening length of $5d$. The following average breaking forces (in cN) were found for the different capillary profiles in the experiments performed on the UZS.A-20: cylindrical, 7.8; oval cross section, 8.5; and oval cross section with a variable-length major axis, 8.0. The following average breaking forces (in cN) were found for the different capillary profiles in the experiments performed on the EM 4020 B: cylindrical, 7.6; oval cross section, 8.2; and oval cross section with a variable-length major axis, 8.3. On the basis of further experiments and a regression analysis, given a maximum microweld strength of 9.96 cN, the following capillary opening dimensions were recommended (for a tool with an oval capillary opening having a variable-length major axis): $x_1 = 1.5d$ (50 μm), $x_2 = 1.7d$ (60 μm), and $x_3 = 7d$ (240 μm). Figures 2, table 1; references 2 (Russian).

Laser Welding Thin-Walled Titanium Alloy Structures Along the Laser Cut

937D0141E Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 p 16

[Article by S.A. Fedorov, Moscow Aviation Technology Institute imeni K.E. Tsiolkovskiy; UDC 621.791.72:621.375.826]

[Abstract] A study examined the feasilibty of using a laser beam to weld thin-walled structures made of titanium alloys along the laser cut. The cutting and welding experiments were performed on 0.3- to 0.4-mm-thick specimens of OT4 titanium alloy. The Kvant laser unit used provided a pulse energy of 15 J with a heating spot diameter of 0.3-1.5 mm and a pulse-following frequency of ≤20 Hz. The unit was capable of producing linear and annular cuts when cutting and welding flat and tubular billets. The cutting and welding were conducted in a shielding gas medium. The quality of the cuts and welds was evaluated based on the results of mechanical tests and metallographic analyses. The following cutting (welding) parameters were used: pulse energy, 5-6 (3-4) J; heating spot diameter, 0.3-0.4 (0.6-0.8) mm; and speed, 2-2.5 (2.5-3) mm/s. The side edges of the cut were found to be virtually free of crystallized metal, and the cut formed with a perpendicularity error (taper) of ≤0.03 mm and a roughness of 0.02 mm. A ≤0.5-mm-high burr formed on the lower edge of the cut. It was easily removed with a scraper before welding. Welding along

the laser cut resulted in a seam 0.6-0.8 mm wide with a weakening amounting to ≤15 percent of the thickness of the sheet. The test welds had an ultimate strength equal to 0.9 that of the basic metal. The plasticity of the weld made along the laser cut was found to be virtually equal to that of the basic metal. The welds produced along a laser cut were found to have practically the same mechanical properties as welds produced mechanically. Table 1.

Welding 10GN2MFA Steel Branch Pipes to the Vessel Equipment of Nuclear Power Plants in a Mixture of Protective Gases

937D0141F Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 21-24

[Article by M.M. Borisenko, candidate of technical sciences, and M.M. Petin, engineer, Machinebuilding Technology Central Scientific Research Institute Scientific Production Association; UDC [621.791.754'29+621.791.754]:54-185]

[Abstract] The Machinebuilding Technology Central Scientific Research Institute [TsNIITMASh] Scientific Production Association developed a new type of wire, i.e., Sv-10G1SN1MchA (patented as Sv-08G1SN1MA), that was used to weld 10GN2MFA steel branch pipes to nuclear power plant vessel equipment. Sv-10G1SN1MchA wire with a diameter of 1.2 mm was used in welding experiments performed in a mixture of 75 percent argon and 25 percent CO_2. In accordance with the applicable branch standard (OST 108.300.02-86), the welding was performed with a current of 200-220 A with preheating at 150-250°C, an arc voltage of 22-24 V, a welding speed of 15 m/h, an electrode gap depth of 15 mm, and a protective gas flow rate of 1,200 l/s. Samples of the metal constituting the weld were subjected to metallographic studies. No weld formation defects were discovered, and the content of alloy-forming elements along the height of the weld remained practically unchanged. The hardness of the metal of welds made by using Sv-10G1SN1MchA wire was on a par (200-230 HV) made with Sv-08GNMA wire and submerged-arc welding with FTs-16 flux. Mechanical tests confirmed that the study welds were in full conformity with the requirements stipulated in OST 108.300.02-86 and that their plasticity and strength indicators were actually better than those specified in the standard. The critical embrittlement temperature of the metal in the test welds remained unchanged even after treatment by thermal cycles for 3,000, 5,000, and 10,000 hours. The cyclic crack resistance of the metal constituting the test welds was practically the same as that of the basic metal, and the test welds also exhibited good static crack resistance. The results of low- and multiple-cycle fatigue tests performed on the study welds also proved satisfactory. The Gospromatomnadzor [not further identified] has approved Sv-10G1SN1MchA (Sv-08G1SN1MA) wire. Figures 6, tables 4; references 3 (Russian).

Plasticity of 15Kh2NMFA Steel During the Welding of Plate Blanks in the 800-900°C Range

937D0141G Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 26-28

[Article by N.N. Podrezov, engineer, A.S. Zubchenko, doctor of technical sciences, and V.A. Reshanov, candidate of technical sciences, Central Machinebuilding Technology Scientific Research Institute Scientific Production Association; UDC 621.791.793:62-413]

[Abstract] During electroslag welding at temperatures of 800-900°C, 5,700 x 5,500 x 240-mm plate blanks of 15Kh2NMFA steel that had been produced by martensite smelting and extrafurnace refining developed cracks in their heat-affected zone. The cracks formed 1-2 grains away from the junction line. A study was conducted to determine the causes of these cracks and the possibility of preventing them. Two welding modes were used during the research. The parameters of the first mode (i.e., a three-electrode scheme) were as follows: $I_{1,2,3}$ = 450-500 A; $U_{1,3}$ = 44 V; U_2 = 42 V; heating temperature, 250°C; and welding speed, 0.5-0.6 m/h. A two-electrode scheme of feeding the wire was also used. Its parameters were as follows: current, 400-500 A; $U_{1,2}$ = 46-50 V; and wire feed rate, 180-220 m/h. The distance between the wires equaled 110 +/- 5 mm, the wire was heated to a temperature of 200°C, and the welding rate was 0.4-0.5 m/h. Metallographic studies established that the main reason for the decrease in the steel's plasticity (and consequently, its development of cracks) at temperatures of 800-900°C is that nonmetal inclusions present in the steel facilitate the formation of hot cracks in the 800-900°C leg of the cooling phase of the temperature cycle of the welding process. Several possible ways of reducing the amounts of microinclusions present were considered and rejected: Elimination of harmful impurities from the steel would increase its cost and sensitivity to the effects of heating and deformation during welding, and reducing the amount of titanium contained in the welding wire would be very complicated owing to the limited selection of available starting materials when the metal is smelted. Instead, it was recommended that the welding process be modified to reduce the temperature and time for which the heat-affected zone is superheated and loaded by distributing the heat evenly during heating and welding. Specifically, the time for which the heat-affected zone is heated to temperatures above 1,150°C should be minimized. Figures 7, tables 4; references 2 (Russian).

The Effect of an External Lengthwise Magnetic Field on the Composition of the Melted Metal of a Weld

937D0141H Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 93 pp 28-30

[Article by A.M. Boldyrev, doctor of technical sciences, V.A. Birzhev, candidate of technical sciences, and A.V.

Chernykh, candidate of technical sciences, Voronezh Construction Engineering Institute; UDC 621.791.753]

[Abstract] A series of experiments were conducted to confirm the beneficial effects of a lengthwise magnetic field on the mechanical properties of the melted metal in a weld. Study specimens of 10KhSND steel were welded in accordance with the conventional submerged-arc process and in a lengthwise magnetic field with an induction of <50 mT. Sv-09GA wire (diameter, 5 mm) and AN-348A flux (containing 41-44 percent SiO_2 and 34-38 percent MnO) were also used. A special electromagnet that made it possible to obtain magnetic flux densities of 0 to 100 mT was used to generate a lengthwise magnetic field with a constant sign. The presence of a lengthwise magnetic field was found to facilitate the transfer of alloy-forming elements into the metal of the weld and to result in welds with improved technological and mechanical properties. Specifically, the lower burnoff and greater intensity of chemical reaction that take place between the molten metal and flux when an external lengthwise magnetic field is present were given credit for these improvements in the welds. In the conventionally produced welds, the actual amounts of C, Cr, Ni, and Cu in the melted metal were lower than the calculated values. In the case of the welds produced in an external lengthwise magnetic field, the amounts of these elements present in the weld increased as the magnetic flux density of the field was increased and approached the calculated values. The amounts of Si and Mn present in the melted metal of the welds exceeded the calculated values in all of the welds produced. The amount of S contained in the melted metal of the weld remained unchanged as the induction of the magnetic field was increased. Figures 3, tables 3; references 5 (Russian).

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